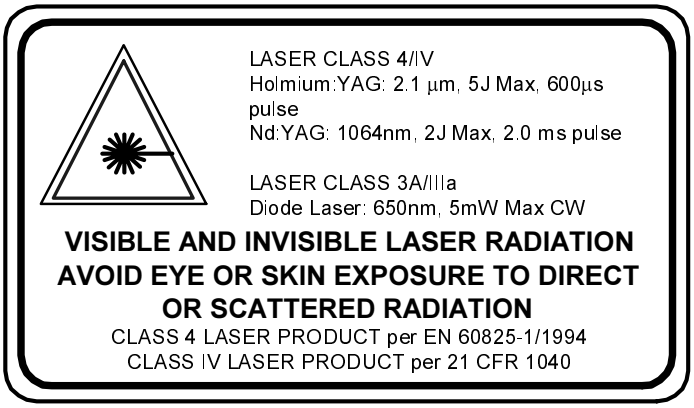
VersaPulse® PowerSuite™
SERVICE MANUAL

This service manual is to be used in conjunction with the operator manual for the product. The operator manual contains important information regarding instrument description, location of controls, specifications, and normal operating procedures.


LASER CLASS 4/IV
Holmium:YAG: 2.1 µm, 5J Max, 600µs pulse
Nd:YAG: 1064nm, 2J Max, 2.0 ms pulse
LASER CLASS 3A/IIIa
Diode Laser: 650nm, 5mW Max CW
VISIBLE AND INVISIBLE LASER RADIATION
AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION
CLASS 4 LASER PRODUCT per EN 60825-1/1994
CLASS IV LASER PRODUCT per 21 CFR 1040

LUMENIS™
Enhancing Life. Advancing Technology.
2400 Condensa Street
Santa Clara, CA 95051
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REV. C

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REVISION INFORMATION

This is the REV. C release of the VersaPulse® PowerSuite™ Service Manual . Contact Lumenis Technical Support to determine if this is the most current release of this service manual.

Each page of this manual has a revision level at the bottom. This indicates the release level for the individual sections. Note that when the manual is updated, not all of the sections are necessarily updated, so some sections may have a revision level earlier than the release revision level for the manual (the revision level for the manual is the revision letter that appears on the cover and in the first sentence of this revision information page). The following list provides a complete list of the revision information, by section, for this release of the service manual.

Cover page, copyright page, disclaimer page, this page, table of contents page(s) are all revision C with the corresponding section(s) of the manual.

SECTION 1	0636-499-01	REV. B	ECO# 69741	DATE: July 2001
SECTION 2	0636-499-02	REV. B	ECO# 69741	DATE: July 2001
SECTION 3	0636-499-03	REV. B	ECO# 69741	DATE: July 2001
SECTION 4	0636-499-04	REV. B	ECO# 69741	DATE: July 2001
SECTION 5	0636-499-05	REV. B	ECO# 69741	DATE: July 2001
SECTION 6	0636-499-06	REV. B	ECO# 69741	DATE: July 2001
SECTION 7	0636-499-07	REV. C	ECO# 69741	DATE: July 2001

NOTE:
Field Service Bulletins (FSBs) released for this service manual are listed in the VersaPulse PowerSuite FSB Index. Each time an FSB for this manual is released or updated, the Index is also updated and distributed with the FSB. The current index is placed behind the single sheet that makes up Section 7, and the FSB's are placed in order behind the Index. Contact Lumenis Technical Support for the date of the most current FSB Index.

SECTION 8	0636-499-08	REV. C	ECO# 69741	DATE: July 2001

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1.0 GENERAL INFORMATION

1.1 USE OF THIS MANUAL

This manual contains service instructions for the Lumenis VersaPulse® PowerSuite™ series of Holmium and Neodymium YAG surgical lasers. The content of this manual is intended solely for use by Lumenis Field Service Engineers and Lumenis trained and certified customer technicians. Lumenis, Inc. cannot be responsible for service or repairs attempted by uncertified persons, and the use of this manual by such persons is prohibited.

This manual is to be used in conjunction with the Lumenis Operator Manual for the VersaPulse PowerSuite laser. The operator manual contains important information regarding instrument description, location of controls, specifications and normal operating procedures.

As necessary, Lumenis Service Technical Support releases Field Service Bulletins (FSB) for the VersaPulse PowerSuite laser. These FSB's supplement the information in this manual. As they are released, the FSB's become a part of this manual (Section 7).

1.2 CONVENTIONS USED IN THIS MANUAL

Within the text, logic signals that are active low ("notted") will appear inside of slash marks, as illustrated below.

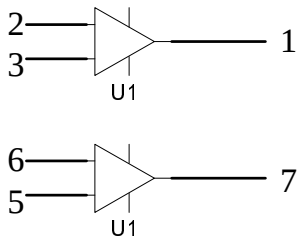
/ ATTENIN /

These signals are "active", or true, when the logic level is low. When the logic signal / ATTENIN / is low, the attenuator loop is "OK" (complete). When the logic signal / ATTENIN / is high, the attenuator loop is not OK (open). In most of the schematic diagrams such signals are indicated by the usual solid line above the signal name, as illustrated below.

$\overline{\text{ATTENIN}}$

The schematics in this manual do not include individual numbers for the logic elements or operational amplifiers within a single component. For example, U1 which is illustrated on the next page, contains two

operational amplifiers. The top op amp would be referred to as U1-1 (its output is pin 1) and the other would be referred to as U1-7.



1.3 SERIAL NUMBERS

Serial numbers for the VersaPulse PowerSuite laser are in the following format:

MYPHWVXXX

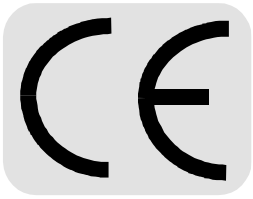
where M is the month produced
("A" is January, "B" is February, etc..)
Y is the last digit of the year produced
(0 is 2000, etc..)
P is a number indicating maximum system power
(9=100W, 6=60W, 4=45W, 3=30W)
(D=60W Ho/100W Nd, E=80W Ho/100W Nd)
H is the number of laser heads installed (1, 2, 3 or 4)
W is a number indicating the mix of rods intalled
(see below)
V is a number indicating power supply configuration
(1= 220VAC single phase)
2XXX is the number of the laser built
(2001, 2002, etc..)

W: 3 = Holmium only
4 = Ho/Nd:YAG

1.4 CERTIFICATION OF COMPLIANCE

The VersaPulse PowerSuite laser is designed and tested in accordance with Lumenis's procedures for self certification for a CE mark.

The CE mark is a certification label which allows Lumenis to sell the VersaPulse PowerSuite Lasers throughout the European community. This label certifies that the VersaPulse PowerSuite laser meets all regulations set forth by various countries in Europe. It is important to ensure that this label is on the laser chassis.



93/42/EEC
0086

1.5 SERVICE INFORMATION & FDA COMPLIANCE

In compliance to the FDA, brochures and specifications sheets must include a reproduction of a complete warning logotype or Class IIa warning statement as required on the product (1040.10(h)(2)(i)). Servicing information must contain the following (1040.10(h)(2)(ii)):

- Procedures for service with appropriate warnings to avoid exposure. (Refer to Section 3)
- A schedule of maintenance to maintain the product in compliance (Refer to Section 3)
- A list of controls that could increase the level of accessible radiation.
  - The energy UP / DN buttons on the LCD touch screen display.
  - The power UP / DN buttons on the LCD touch screen display.
  - The energy UP / DN buttons on the remote control display.

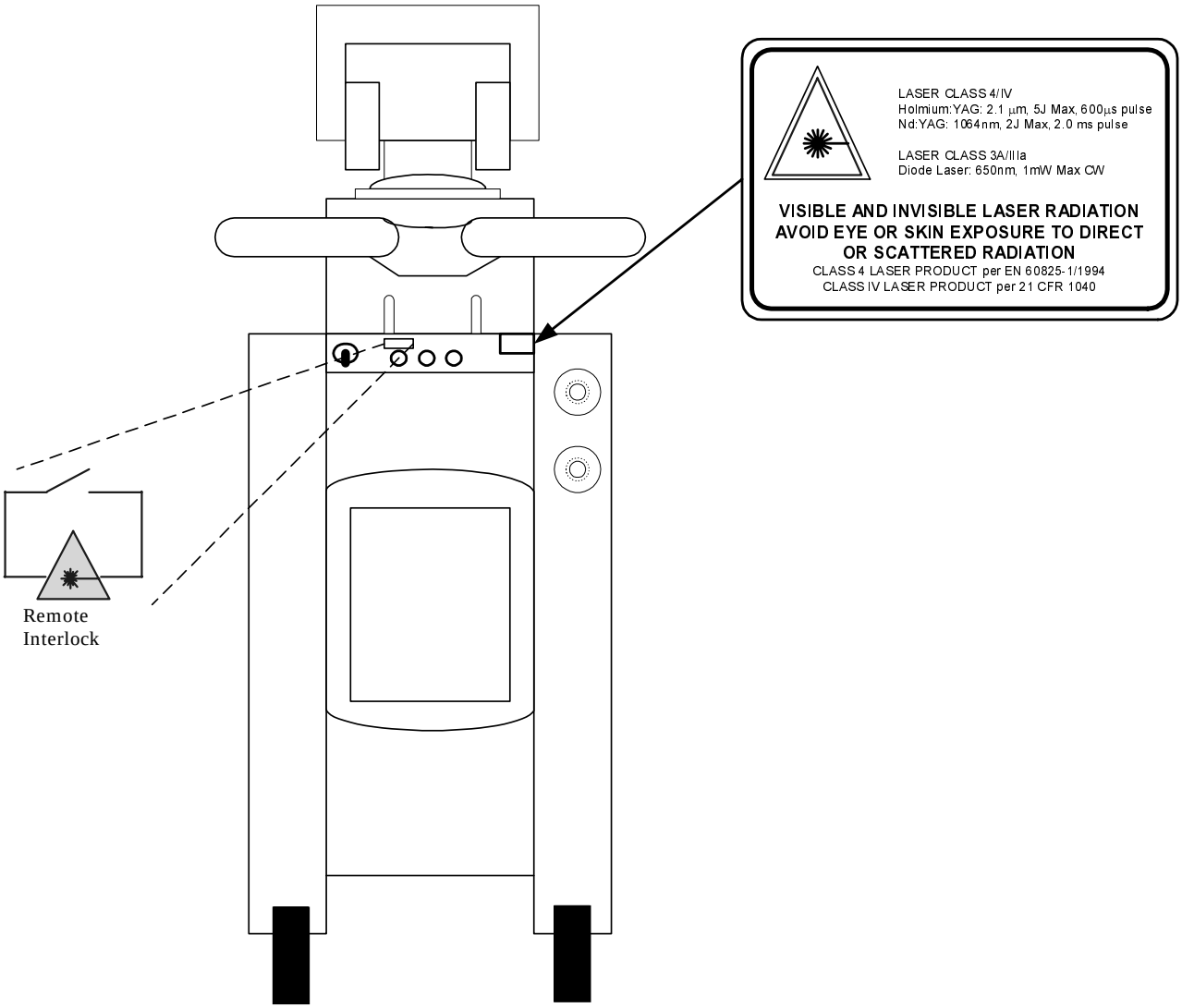
•• The power UP / DN buttons on the remote control display.

• Identification of removable portions of protective housings. (Refer to Section 5)

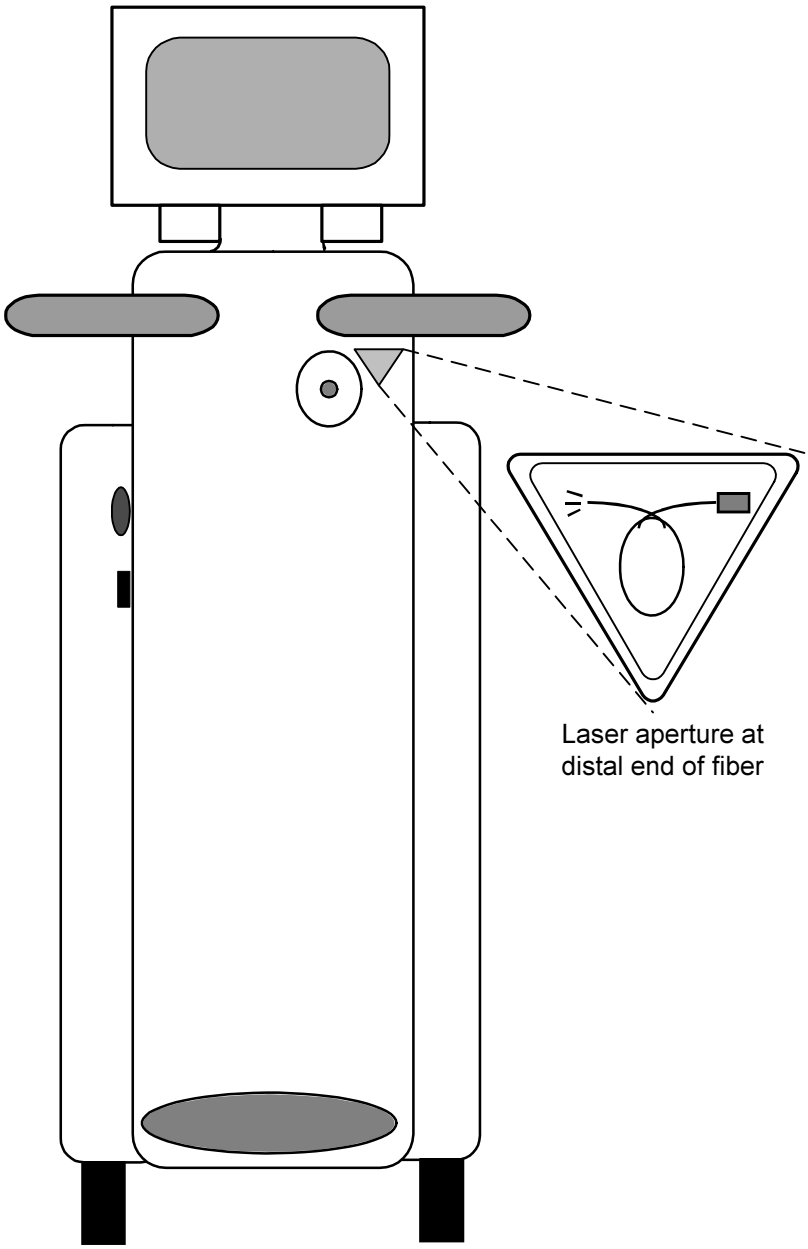
• Procedures to avoid exposure. (Refer to Section 3)

• Reproductions of required labels and warnings.

•• Below are illustrations of required labels and warnings applicable to this Service Manual:


LASER CLASS 4/IV
Holmium:YAG: 2.1 μm, 5J Max, 600μs pulse
Nd:YAG: 1064nm, 2J Max, 2.0 ms pulse
LASER CLASS 3A/IIIa
Diode Laser: 650nm, 1mW Max CW
VISIBLE AND INVISIBLE LASER RADIATION
AVOID EYE OR SKIN EXPOSURE TO DIRECT
OR SCATTERED RADIATION
CLASS 4 LASER PRODUCT per EN 60825-1/1994
CLASS IV LASER PRODUCT per 21 CFR 1040
Remote
Interlock

(REAR VIEW)



(FRONT VIEW)

2.0 INSTALLATION

2.1 INTRODUCTION

WARNING: Installation by untrained persons is a potential hazard to the persons doing the installations, others present, and to the equipment itself. In addition, improper installation is a potential hazard to the user, persons present during use, and patient.

These installation instructions are provided for use by Lumenis Service Engineers who have completed certification service training on the VersaPulse® PowerSuite™ laser. Installation by untrained persons is a potential hazard to the person or persons performing the installation, others present and to the equipment itself. In addition, improper installation is a potential hazard to the user, persons present during use and patient.

2.1.1 Site Inspection

1. Check for proper site set up. This includes proper AC service and adequate space for the console.

AC power configuration: The VersaPulse PowerSuite requires 220 VAC±10%, 50/60 Hz, 30 Amps (32 Amps for 100W Holmium) single phase electrical service. The power cord is a 26 ft. cable with two conductors and a ground. An AC Control PCB behind the right side cover allows for tapping of the isolation transformer to the setting closest to the incoming electrical service. The system can be hard wired to the electrical service or installed to the electrical service with a plug and receptacle. Customers are responsible for supplying electrical connections (i.e., electrical receptacle and mating plug).

Console dimensions and weight: The console measures 36” L x 18” W x 39” H. It weighs approximately 350 lbs. A minimum of 18” of air space is required around the unit to provide adequate cooling air circulation.

The system requires approximately 2.5 gallons of distilled water for its closed loop cooling system. The coolant must be added as described in this procedure.

Complete specifications for the VersaPulse PowerSuite laser are included later in this section and in the VersaPulse PowerSuite laser Operator Manual. Contact Technical Support in Santa Clara, CA. if there are any questions concerning site preparation.

2. Verify the AC mains voltage at the site.

Frequency:	50 / 60Hz
Voltage:	220 VAC ±10%
Current:	30A (32A for 100W Holmium)
Phase:	Single (ϕ)

2.1.2 Unpack & Inspect Laser

1. Check the crate/carton for any shipping damage.

The shipper is responsible for any damage to the system in shipment. If the crate / carton appears to be damaged, report the damage to the customer and shipper.

2. Remove the console and accessories from the crate (refer to Fig. 2.1).

a. Loosen the six butterfly clamps securing the side door and lower the side door (the side door is used as a ramp to remove the console from the crate). Remove the protective foam and accessories box. Install the ramps onto the base, then roll the unit down the ramps.

b. Return all packing material to the crate and save for future use.

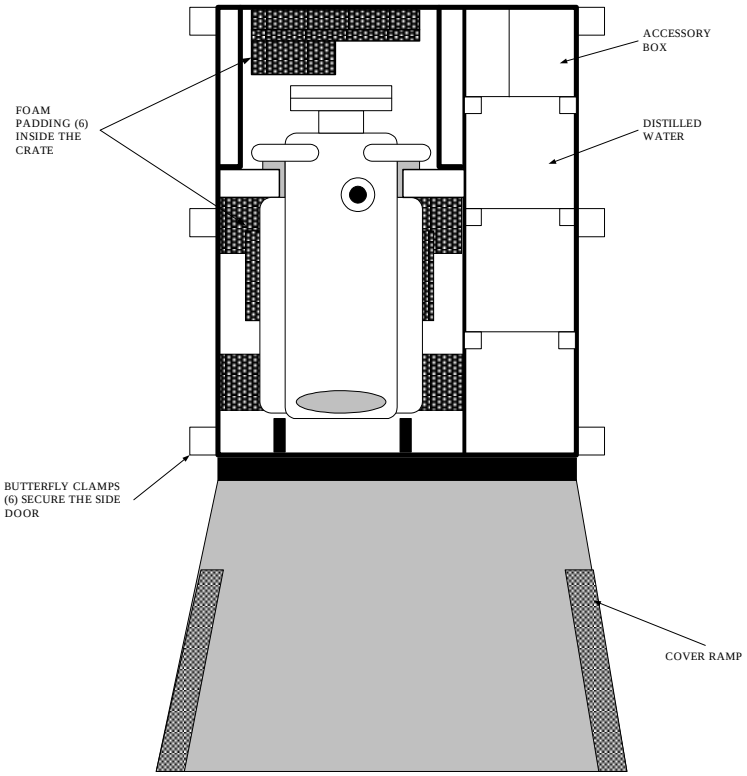


FIG. 2.1
SHIPPING CRATE

3. Move the system to its installation location.

The VersaPulse PowerSuite laser rolls best when pushed from the front handles. The front wheels swivel, the rear wheels do not.

4. Open/remove covers and do a visual inspection of the interior.

Refer to Section 5 for information on removing the covers. Open the front cover, then remove the top and two side covers. Inspect the interior carefully for loose or broken electrical or optical connections, loose or broken plumbing connections, or any indication of shipping damage.

2.1.3 Configure AC Control PCB

Refer to Section 3.3.1 for additional details.

1. AC voltage configuration preparation.

a. Measure the mains voltage and record.

b. Verify the VersaPulse PowerSuite is not connected to the AC mains.

2. Locate the AC Control PCB (behind the right side panel) and identify TB5 & TB2 (top of the PCB). Refer to Fig. 2.2.

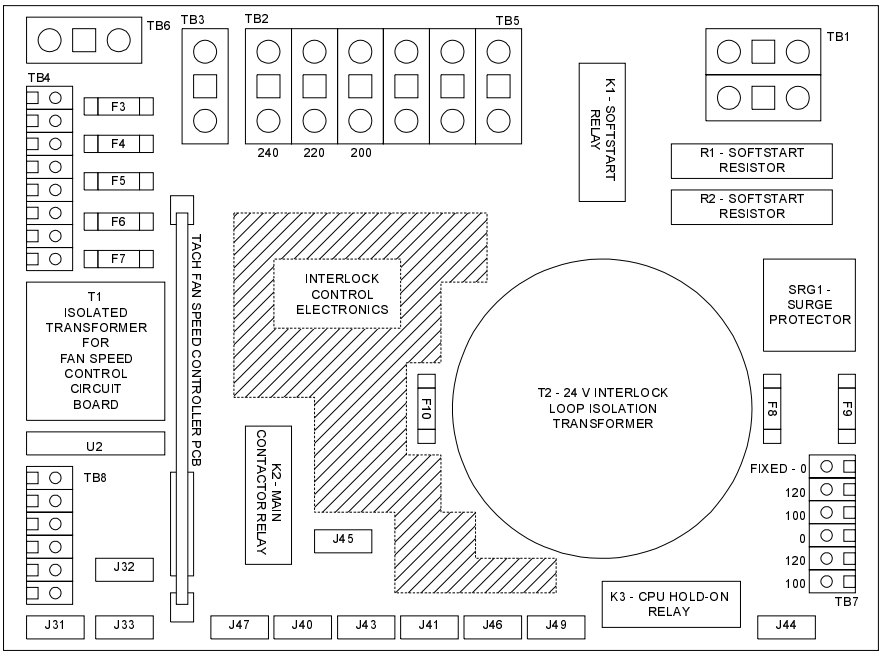


FIG. 2.2 AC CONTROL PCB

3. Locate the large brown wire in TB5-1 and position the other end in TB2 as follows:

a. For mains voltage in 190 - 210 VAC range, connect TB5-1 to TB2-2.

b. For mains voltage in 211 - 230 VAC range, connect TB5-1 to TB2-3.

c. For mains voltage in 231 - 264 VAC range, connect TB5-1 to TB2-4.

4. Locate the two small blue jumper wires in TB7 (bottom right). Position the jumpers as follows:

a. For mains voltage in 190 - 210 VAC range, jumper TB7: 1-3, 4-6.

b. For mains voltage in 211 - 230 VAC range, jumper TB7: 1-3, 5-6.

c. For mains voltage in 231-264 VAC range, jumper TB7: 2-3, 5-6.

5. Record the voltage range on the Certification Report.

6. Connect to AC service.

CAUTION: Once connected to the site electrical service, lethal voltages are present inside the unit. The AC power is present at the circuit breaker, main contactor and the AC Control PCB. Review and understand the safety subtopic in Section 5 before proceeding.

The system can be hard wired to electrical service, but is more typically connected by a plug to an electrical outlet.

If the system is to be hard wired, the customer must provide an electrician to wire the cord end into the electrical service outlet. A lockable electrical service disconnect switch must be installed if the system is hard wired.

If the system is to be plugged into an electrical receptacle, the appropriate receptacle should already be installed by the customer's electrician. The installing engineer connects the plug to the end of the VersaPulse PowerSuite electrical cable.

2.1.4 Add Coolant

Add coolant (distilled water) to the fill reservoir. The coolant will drain out of the fill reservoir and into the main reservoir. The system uses approximately 2.5 gallons of coolant. Most coolant can be added at this time - until the fill reservoir level stays up. The system coolant level will be "topped off" after the system is turned on (in a later step).

NOTE: Use distilled water only! Do not use alcohol or glycol based additives.

2.1.5 Turn On

CAUTION:

- Once the circuit breaker is turned on and power is applied to the VersaPulse PowerSuite laser, wait a few minutes and observe for any indication of failure of the mains or turn-on components. Check for any coolant leaks.

- The system will fire during the turn-on sequence regardless if SW3 (Autocal) on the CPU PCB is left or right and the BRH plug is installed. Only those persons required should be present during this portion of the installation - those present must wear appropriate laser safety eyewear and follow all laser safety precautions.

- The cooling fan blades are not covered. The fan is located on top of the heat exchanger. It operates whenever the system is turned on. Keep tools, system parts and body parts clear of the fan blades.

1. **Turn and hold the keyswitch to the START position, then after approximately two seconds, release it to the ON position. The system will go through its start up sequence. Observe for normal start up, and for any indication of leaks in the cooling system.**

2. **Add additional coolant if necessary.**

   NOTE: Only add water if disconnected from AC mains.

   Turn system off and disconnect from the AC mains. Top off the fill reservoir. Reconnect to AC mains and cycle the machine off and on several times, adding coolant as necessary until the fill reservoir level stays up to approximately half full as the system runs.

3. **Perform Fiber Alignment Test, Verify Calibration procedure and the Operational & Safety checks in Section 3.**

4. **Replace all covers and prepare the system for demonstration to the customer.**

2.1.6 Customer Demonstration

1. **Demonstrate the system operation to the customer.**

2. **Fill out and mail the "self mailer" installation quality audit report (for U.S. Field Service).**

3. **Fill out the System Certification report.**

2.2 PRODUCT SPECIFICATION

Specifications are subject to change without notice.

VersaPulse Power Suite Dual Wavelength laser

Treatment beam wavelengths

Ho:YAG (2.1µm)
Nd:YAG (1.06µm)

Table 1: 60/100W Model

Wavelength	Power	Energy	Exposure Time	Pulse Rate	Pulse Width
Ho:YAG (2.1µm)	0 - 60W	0.2 - 3.5 J*	n / a	5 - 40 pulses / sec.*	600µs Max
Nd:YAG (1.06µm)	0 - 100W**	0.08 - 1.67J	0.1 - 180 sec.* or continuous	60 pulses / sec.	2ms Max

Table 2: 80/100W Model

Wavelength	Power	Energy	Exposure Time	Pulse Rate	Pulse Width
Ho:YAG (2.1µm)	0 - 80W	0.2 - 3.5 J*	n / a	5 - 40 pulses / sec.*	600µs Max
Nd:YAG (1.06µm)	0 - 100W**	0.08 - 1.67J	0.1 - 180 sec.* or continuous	60 pulses / sec.	2ms Max

* adjustable in variable increments
** adjustable in 5 Watt increments

VersaPulse PowerSuite Holmium laser

Treatment beam wavelength

Table 3: Ho:YAG (2.1µm)

Model	Power	Energy	Pulse Rate	Pulse Width
30 Watt Ho:YAG	30W	0.2 - 3.5J	5 - 25 pulses / sec.	600µs Max
45 Watt Ho:YAG	45W	0.2 - 3.5j	5 - 40 pulses / sec.	600µs Max
60 Watt Ho:YAG	60W	0.2 - 3.5J	5 - 40 pulses / sec.	600µs Max
100 Watt Ho:YAG	100W	0.2 - 3.5J	5 - 50 pulses / sec.	600µs Max

VersaPulse PowerSuite Dual Wavelength and Holmium lasers

Laser Classifications:

US FDA CDRH laser classification: Class IV
European EN 60825 laser classification: Class 4

Aiming Beam:

Type: Diode
Power: 1 mW maximum, Continuous Wave
US FDA CDRH laser classification: Class IIIa
European EN 60825 laser classification: Class 3A
Principal output: Red, 650nm (±10 nm)

Input Power

Frequency: 50 / 60 Hz
Voltage: 220 VAC ±10%
Phase: Single
Current: Holmium 100W systems, 32A
All other Holmium systems, 30A
Dual wavelength systems, 30A

Cooling

Internal water-to-air heat exchanger or optional secondary cooling system

Cooling air requirements

Minimum 46 cm (18 in.) from walls

Physical characteristics

Width: 46 cm (18 in.)
Length: 91 cm (36 in.)
Height: 99 cm (39 in.)
Weight: 163kg (360 lbs.)

Power cord length

8.0 m (26 ft.)

Footswitch cable length

3.7 m (12 ft.)

Environmental requirements (operating)

Maximum altitude: 3,050 m (10,000 ft.)
Temperature range: 10• C to 30• C (50• F to 86• F) - must be above dew point
Maximum humidity: 90% at 27• C (81• F) non-condensing

Environmental requirements (non-operating)

Maximum altitude: 9,144 m (34,564 ft.)
Temperature range: 10• C to 50• C (50• F to 122• F) - must be above dew point
Maximum humidity: 90% at 55• C (131• F) non-condensing

Optional external cooling system

Cooling capacity: 4.5 kW
Flow rate: 0.25 lps (4gpm)
Temperature set point: 20• C (68• F)
Connections: Quick connect
Line size: 1/2 inch minimum

Compatible delivery systems: (The laser is intended for use only with Coherent-qualified delivery systems)

3.0 CALIBRATION, ADJUSTMENT & ALIGNMENT

3.1 INTRODUCTION

3.1.1 Overview

This section contains procedures for the checks and adjustments required to maintain the Lumenis VersaPulse® PowerSuite™ Laser. The procedures assume the reader has successfully completed a Lumenis service training course on the VersaPulse PowerSuite laser. Service performed by untrained or unqualified persons can be a hazard to the person or persons doing the service and to others present during the servicing. An improperly serviced medical system can be a hazard to the equipment user, to others present during use, and to the patient upon whom the laser is used.

The procedures should be performed in the order presented, from beginning to end. If only a portion of the procedures are done, the servicing engineer must consider the possible effect of doing just that portion of the procedures (i.e., there may be adjustments done earlier or later in the procedures that impact or are impacted by the portion performed).

Optical Alignment, Topic 3.2, this is performed when the System Check out procedure indicates a problem, any of the various optical / electro-optical / servo components have been adjusted / replaced or the system cannot meet specifications during the various calibration procedures.

Electrical Adjustments, Topic 3.3, verifies the Fan Speed Controller PCB is properly adjusted for optimal cooling and the speaker volume is properly adjusted.

Mechanical Adjustments, Topic 3.4, verifies that various mechanical switches and latches are properly set.

Energy Calibration, Topic 3.5, calibrates the voltage output of the two energy monitor circuits to the Field Service Engineer's calibrated power meter.

System Optimization Check, Topic 3.6, verifies that the system is operating optimally after the preceeding procedures (i.e., optical, electrical and etc.) have been completed and test the calibration at all operating points.

Operational and Safety Check, Topic 3.7, is an operational check of the system. It confirms that the system turns on properly, responds properly to operator inputs, delivers the multiplexed YAG beam into the center of an attached fiber, and provides an adjustable aiming beam through the fiber. It also confirms that the proper fault messages are displayed when various connectors (i.e., footswitch and remote interlock plug) are disconnected and the system is prevented from firing.

Periodic Maintenance, Topic 3.8, provides information on periodic maintenance checks to ensure optimum performance of the system.

TOOLS & EQUIPMENT REQUIRED:

Power Calibration Test Fibers
for Ho/Nd 0623-973-01
Field Master
Cross-Hair Alignment Tool 0621-131-51
Zap-It paper 3207-0091
Ink/Burn Test Fiber 0621-675-01
DVM & Leads
10mm Aperture Alignment Tool 0622-919-51
Transimpedance Amplifier 0614-868-51
Calibrated Oscilloscope
FSH Head
Berol 8800 red Marker
Poly Bags

Two test fibers are shipped with the system. Check the fiber focus as described in Section 3, Topic 3.2.

3.1.2 Safety Precautions

Lethal voltages and laser emission are the primary dangers to the servicing engineer. In addition to the general safety precautions which always apply when working on electronics and lasers, the servicing engineer must be aware of the following specific precautions:

- **Only Lumenis certified VersaPulse PowerSuite YAG service engineers should attempt any service on this system.**

- **Even with the keyswitch and the breaker in the "OFF" position there are lethal voltages present inside the console. Always disconnect the main electrical service before working on the console.**

- **Storage capacitors inside the system are capable of holding a lethal charge, even after power has been removed from the unit.** A charge level indicator LED located on the Simmer/Start Control PCB flashes at a rate proportional to the level of charge on the main charging capacitor. The LED can be seen through a small access window on the High Voltage Power Supply cover next to the Controller PCB. Do not rely on this indicator to determine that the main charging capacitor has been discharged. Before contacting the main charging capacitor, disconnect the system from the primary power.

- **Do not touch the YAG Cavity Module when the system is on - IT IS A SHOCK HAZARD.** The YAG Cavity Module is electrically isolated from the chassis and can be at a voltage potential much higher than ground. A Neon lamp on the Starter Indicator PCB indicates lamp start high voltage is present when flashing. B+ is always on the pod's terminal block.

- **Both Holmium & Nd:YAG laser emissions are invisible to the human eye.** Because the YAG laser energy can not be seen, there is no visible indication of the primary or reflected beam. Eye protection that attenuates the YAG wavelengths to a safe level must be worn by all persons in the area of the laser system, whenever the laser is being serviced.

- **The YAG laser light and its reflections are potential burn hazards and can ignite flammable materials.** Use extreme caution when operating the system with covers opened or removed. The covers contain the beam and reflections safely within the console. Only those persons required should be present during servicing and eye protection that safely attenuates the YAG wavelengths must be worn by all present.

- **The YAG laser light and its reflections are potential hazards to the eye and skin.** Use extreme caution when operating the system with the covers opened or removed. The covers contain the beam and reflections safely within console. Only those persons required should be present during servicing and eye protection that safely attenuates the YAG wavelengths should be worn by all those present.

3.2 OPTICAL ALIGNMENT

Perform the Optical Alignment procedures whenever any optical or electro-mechanical device have been replaced or adjusted in the optics bench or in the laser head. *Note that the procedures should be performed in the order presented, from beginning to end. If only a portion of the procedures are done, the servicing engineer must consider the possible effect of doing just that portion of the procedures (i.e., there may be adjustments done earlier or later in the procedures that impact or are impacted by the portion performed).*

3.2.1 Folding Mirror Alignment

This is not normally performed in the field. contact Lumenis Technical Support Department for additional tooling and instructions if required to perform this alignment.

3.2.2 YAG Channel Alignment

When properly adjusted the YAG channel will meet each of the following three criteria.

- The cavity HR will be positioned to direct the YAG output to the center of the first relay mirror, and the cavity OC will be positioned to provide maximum power for that HR position.

- The first relay mirror and second (plano) relay mirror will direct the YAG energy off the two folding mirrors so that it is centered through the wedge optic apertures and centered into the proximal end of the fiber.

The adjustment procedure for a single channel follows. The procedure is a complete check out and alignment for a single channel. The procedure is meant to be done in the order given, from beginning to end.

It may often be appropriate to do less than the complete adjustment, but in such a case the field service engineer must consider the possible effect of doing only a portion, i.e., the adjustment may have an effect on some other portion of the alignment. As an example, if a single channel is only slightly out of center at the fiber port, it can usually be corrected by simply adjusting the first relay mirror (using the fiber detector signal) and then confirming the adjustment using a test fiber burn.

When replacing a damaged optic, it should not be necessary to do the entire procedure. Try to bring the system back into alignment by adjusting the optic that was replaced.

3.2.2.1 Making Test Burns

(Refer to Fig 3.2 and 3.3) Checking out and aligning the YAG channels requires making burns on photopaper to check alignment. The Alignment Aperture and Cross Hair Aperture are two special purpose tools used when making burns.

In general, when making burns, lower pulse energies and fewer total pulses are better. As the total energy of the burn increases, the footprint becomes "blurred". In some cases it will be necessary to get a "multiplexed footprint", i.e., the paper is burned by more than one channel, allowing the YAG beam positions to be compared. In other cases a single channel burn will be required. The service engineer can select the channels to be fired, a lamp current and a pulse rate at the service screens. Setting a lower pulse rate allows the footswitch to be operated to obtain just a single pulse from a channel, or from each selected channel.

The alignment aperture is used to center the YAG beam(s) in front of the second wedge optic. It holds a piece of burn paper (covered on both sides with plastic to contain splatter). A good burn will fall inside the aperture (the aperture will not clip the beam). The tool is keyed with two small posts that fit into holes on the face of the second wedge optic housing block. To use the aperture, slide burn paper and plastic in through the side, then insert it on the second wedge optic housing.

The cross hair aperture is used to align an individual cavity (OC and HR) into the center of the first relay mirror. To install it, the first relay mirror mount is removed, then the aperture slides into a hole in the wall directly behind the spot the channel first relay mirror was mounted (insert from the outside of the wall, so that it is further from the channel OC). The aperture has two small wires running across it that block a small portion of the beam (perpendicular to each other and crossing in the center of the aperture). The resulting burn will have the cross hairs superimposed on it. The cavity optics are adjusted to center the burn in the cross hairs.

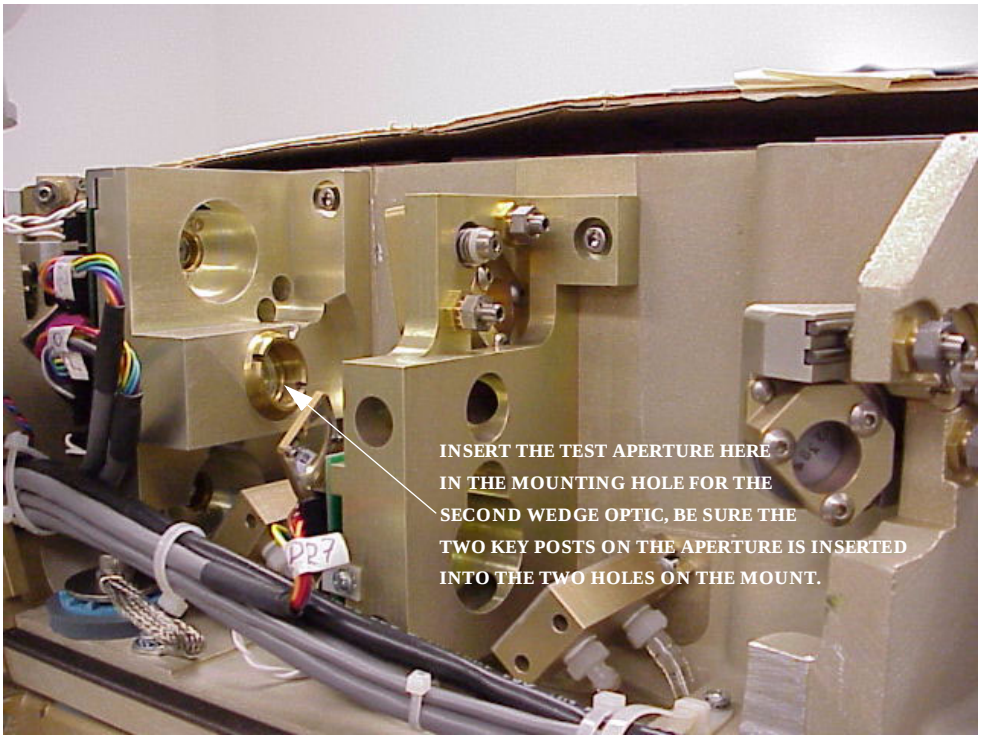

INSERT THE TEST APERTURE HERE
IN THE MOUNTING HOLE FOR THE
SECOND WEDGE OPTIC, BE SURE THE
TWO KEY POSTS ON THE APERTURE IS INSERTED
INTO THE TWO HOLES ON THE MOUNT.

FIG. 3.1

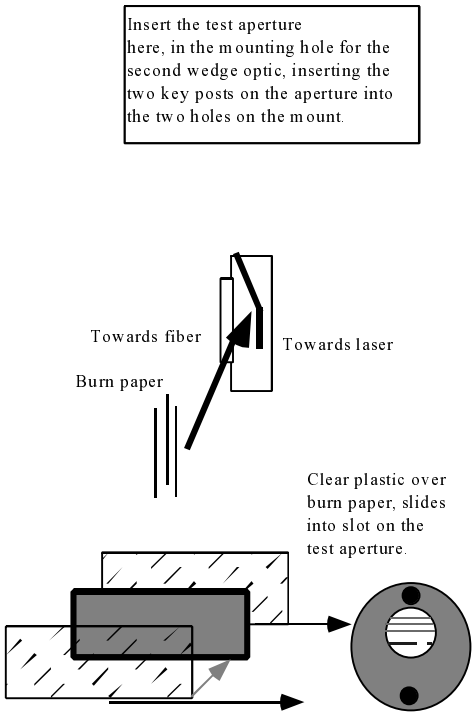

Insert the test aperture here, in the mounting hole for the second wedge optic, inserting the two key posts on the aperture into the two holes on the mount.
Towards fiber
Towards laser
Burn paper
Clear plastic over burn paper, slides into slot on the test aperture.

FIGURE 3.2 USING THE TEST APERTURE

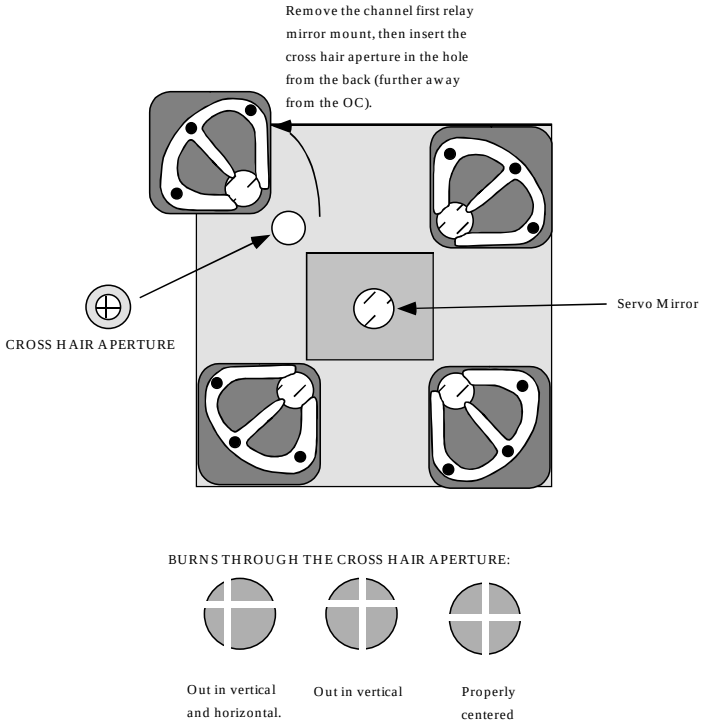

Remove the channel first relay mirror mount, then insert the cross hair aperture in the hole from the back (further away from the OC).
CROSS HAIR APERTURE
Servo Mirror
BURNS THROUGH THE CROSS HAIR APERTURE:
Out in vertical and horizontal.
Out in vertical
Properly centered

FIG. 3.3: USING THE CROSS HAIR APERTURE

3.2.2.2 Adjusting the YAG Channel Optics

WARNING! When the optics bench cover is removed, exposure to hazardous high voltages is present. 10kV is present on the pod assembly when the lamps are starting, and may be present any time the system is turned on. B+ is present on the terminal block whenever the system is on, and is present up to 15 minutes after the system is turned off.

Refer to Fig. 3.4 The channel HR, OC and relay mirrors all have the same basic adjustment mechanics. The mirror is held in a mirror mount by a metal retainer. The mount attaches to one of the optics bench walls by a single mounting screw with spring. The spring pulls the mount towards the wall - two adjusting screws and a ball bearing hold the mount out away from its mounting surface against the tension of the spring. One adjusting screw provides horizontal movement and the other provides vertical movement.

A locking nut is threaded onto each adjusting screw. To unlock the screw for adjustment back the locking screw away from the collar. Once adjustment is complete, lock down the adjustment screw by turning the nut down against the collar. As is common in such mechanical lock down set ups, the locking down process will change the adjustment a bit, so use the locking down to bring the optic to its optimum position. It is best to use the hex wrench to hold the adjusting screw in place while tightening down the locking nut with the box end wrench. **The adjusting screws require a 7/64th hex head wrench. The locking nuts require a 7/16th box end wrench.**

The channel HR and OC must first be aligned to each other through the length of the YAG rod in order to achieve lasing. Once the two mirrors are aligned to provide a usable output (will make a burn on photopaper), the two optics are adjusted together to "walk" the YAG output so that it is centered in the first relay mirror. Finally, the OC is adjusted to peak the power out of the cavity into the center of the first relay mirror.

The channel first and second (plano) relay mirrors are adjusted to center the channel YAG beam through the wedge optics and into the center of the fiber port. The first relay mirror is the far (fiber port) adjustment (it is concave, and provides less positional change to the beam downstream at the fiber port). The second relay mirror is near (wedge optic) adjustment, it moves the beam much more than the first relay mirror. In general, unless the beam is grossly out of center at the second wedge aperture, the second relay mirror should not be adjusted.

There are also two turning mirrors that steer all the YAG channels off the galvo/servo mirror down towards the fiber port. These mirrors do not normally require adjustment. Obviously, adjusting one of these mirrors will affect all four YAG channels. The adjustment and mounting scheme is the same as that for the channel optics.

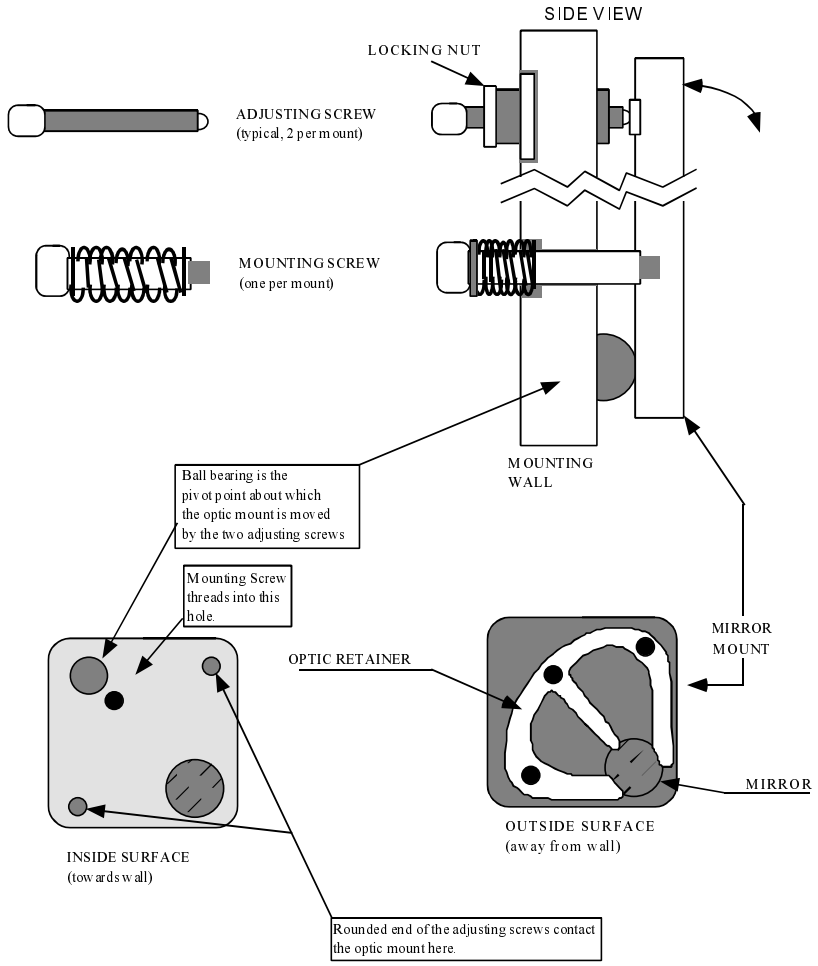


FIG. 3.4: ADJUSTMENT AND REPLACEMENT OF THE CHANNEL OPTICS

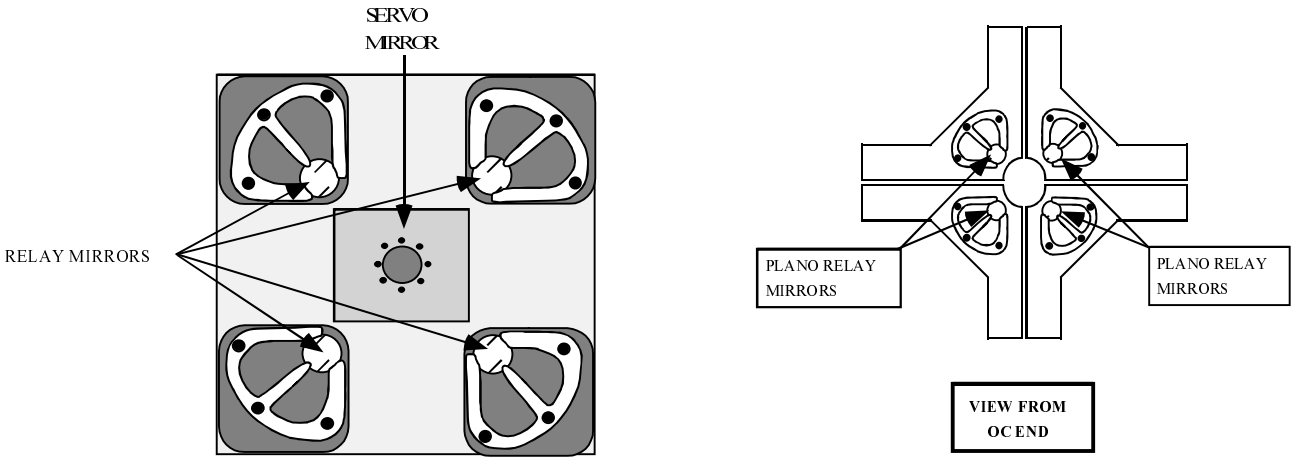


FIG. 3.5: RELAY AND PLANO MIRRORS (Ho/Nd:YAG)

First Relay Mirror - far (fiber) alignment

Plano Mirror - near (wedge) alignment

3.2.2.3 Resonator Alignment

1. Remove the optics bench cover.

2. Examine the optics for any visual sign of damage. Replace damaged HR, OC, or Relay mirrors.

(Refer to Fig 3.4 on the previous page) To replace a channel relay mirror, HR or OC, first remove the mirror mount by carefully removing the mounting screw (it has a spring around its shaft to place tension on the mount) while supporting the mount. Once the mount is free, set it down face up and remove the retainer (held in place by three hex screws) that hold the optic. The old optic can then be removed and the new optic inserted (ball bearings inside the mounting hole center and the optic in the hole). Reinstall the retainer, then the mirror mount. Note that the mount should return to its former position, since the adjustment screws were not removed.

3. Examine the end of the rod for visual damage.

The rod will be illuminated by the flash lamp when the unit is on (if not, the flash lamp has failed or the simmer supply circuitry has a problem). Replace a damaged rod or failed flash lamp.

4. Center and peak the cavity output into the first relay mirror.

When the cavity OC and HR are correctly aligned, the YAG beam will be centered in the relay mirror directly across from the OC, and the cavity power output will be peaked.

a. Remove the first relay mirror mount and place a piece of "Zap-it" or Dioptron paper just in front of where the first Relay Mirror was removed.

b. Set the laser in service mode with the following parameters:

Typically, the burn diameter is approximately 4mm in diameter. If the burn is small, perform the cavity alignment and increase the lamp current. The burn diameter may get larger.

A B

An oblong burn spot indicates that the HR and OC optics are not properly aligned for maximum power. Burn "A" shows mis-alignment in the X-axis, while burn "B" shows misalignment in both X and Y.

Good cavity power is shown. A large diameter burn (approx. 4mm) indicates good power. No adjustment of the HR or OC is necessary.

For Ho: (for power measurement	Lamp Volts	800V	(For Centering)	Lamp Volts	800V
	Lamp Energy	50J		Lamp energy	50J
	Repetition Rate	10 Hz		Repetition Rate	1.3 Hz

For Nd: (for power measurement)	Lamp Volts	800V	(For Centering)	Lamp Volts	800V
	Lamp current	50A		Lamp current	50A
	Repetition Rate	60 Hz		Repetition Rate	5 Hz

Turn on only one flashlamp when aligning the cavity. After one channel is aligned, turn off the flashlamp for that particular channel and then turn on the flashlamp for the next channel to be aligned.

c. Make a single burn on the paper and compare the burn to the drawing below.

d. Adjust the X or Y axis on the OC mirror mount to optimize the alignment of the beam.

e. Install the cross hair aperture (as described in 3.5.1).

f. Make a burn (single channel) through the cross hair aperture onto a piece of burn paper.

g. Examine the burn to determine if the YAG beam is centered.

The burn should be centered over the cross hairs. If not, adjust ("walk" as described in the following subparagraph) the OC / HR positions to bring the burn into center, rechecking as necessary as in step "b" above. Continue adjustment until the burn footprint is centered in the cross hairs.

"Walking" the beam refers to the method of adjusting the OC and HR in the same direction and distance, so that the two mirrors remain in the same orientation with each other, but are brought to a new orientation with respect to the rod. Each mirror mount has a horizontal and a vertical adjustment screw. For example, to walk the beam "up" with respect to the hole, the OC vertical adjustment would be turned in, then the HR vertical adjustment would be

turned out the same amount (do not be fooled as to the direction to turn the adjustment screw by the fact that the two screws are mounted in opposite directions - one screw is being turned in and the other is being turned out, but because the screws are mounted in opposite directions the screws rotate in the same direction).

h. Once the burn has been centered in the cross hairs, remove the cross hair aperture and place the power meter head behind the hole, so that the YAG energy through the hole will strike the power meter head. Fire the laser into the head and adjust the OC to peak the cavity power output.

i. Replace the cross hair aperture and recheck the beam centering through the hole as in step "b" above. Some slight readjustment of the HR may be necessary to recenter the burn in the cross hairs.

j. Repeat steps "d" and "e" until the power is peaked and the burn is centered in the cross hairs, with the HR and OC adjustment mechanisms locked down.

k. Reinstall the first Relay Mirror and perform the Fiber Alignment Procedure in Topic 3.6.

3.2.3 Servo Mirror Alignment

NOTE: Only perform this procedure if either the servo mirror or servo motor are replaced.

1. Turn off the laser and disconnect from the wall.

2. Removing and replace the motor/encoder assembly.

a. Disconnect the cables from the motor / encoder assembly and remove the mirror mount from the motor shaft.

b. Remove the six screws behind the mirror and remove the motor / encoder assembly.

c. Install the new motor / encoder assembly in the same orientation as the old one, and reconnect the cables.

NOTE: Shaft rotation is not important at this time.

3. Reconnect the power, disable autocal and turn the laser on.

The motor shaft must always slowly rotate to find the index position on the encoder. LED30 (INDEX) will illuminate green and TP75 “INDEX” will go high.

NOTE: If the service software has lamp #1 turned off, the motor will find the index position and rotate to the next active brick.

4. Install the Servo Mirror.

a. Using the servo alignment tool (P / N 0622-782-51), install the servo mirror on the motor shaft. Be sure the mirror mount is pushed all the way onto the shaft. Refer to Fig. 3.6.

b. Rotate the mirror toward brick #1.

The mirror mount will fit into the servo alignment tool in two different ways. But only one orientation is the correct way.

c. Once the alignment tool is attached properly use the hex key to lock the mirror mount down.

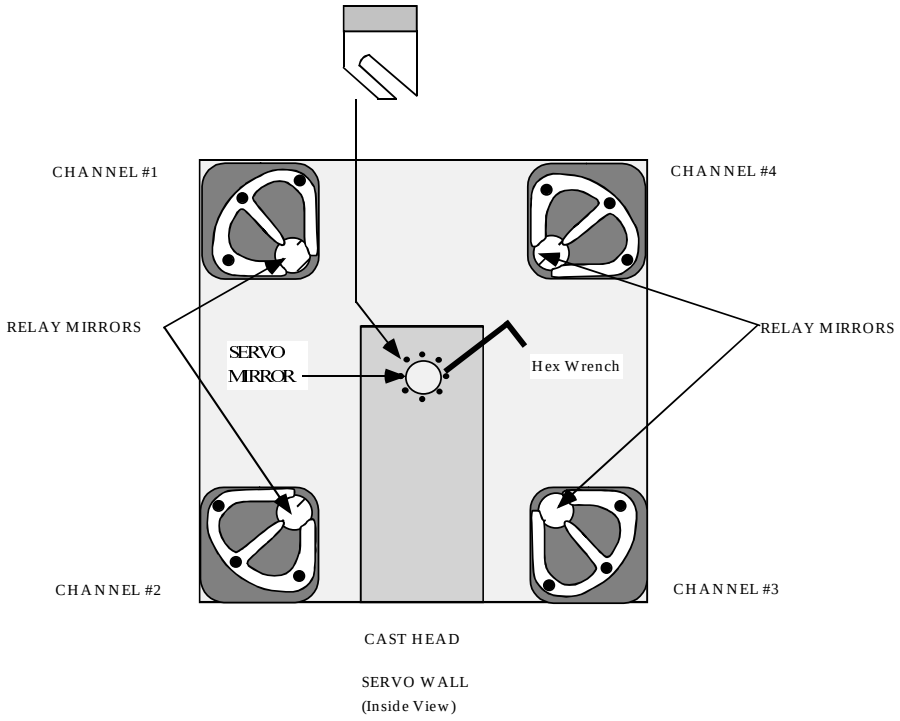


FIG. 3.6: SERVO MIRROR INSTALLATION

5. Perform the Fiber alignment for all channels in Section 3.2.4.

If no laser energy is detected between the two folding mirrors, the mirror is probably not oriented toward the correct brick. Go back and repeat step 3, then rotate the mirror 180• on the shaft in step 4.

3.2.4 Fiber Alignment

For each channel, two optics are adjusted to position the YAG beam down the intended optical path into the center of the fiber; the first relay mirror and the second (plano) relay mirror.

The second relay mirror seldom needs to be adjusted. It provides a much wider range of movement of the beam than the first relay mirror. The four second relay mirrors are all mounted on the cavity OC wall. Although the second relay mirror mounts are shaped differently than the other channel mirror mounts, the mounting and adjusting hardware is the same - each is held in place by a spring loaded mounting screw and each has a horizontal and vertical adjusting screw with locking nut.

The first relay mirror is normally the only adjustment needed to get the YAG beam centered through the wedge optics and centered into the fiber port.

a. Set the system to the following operating parameters.

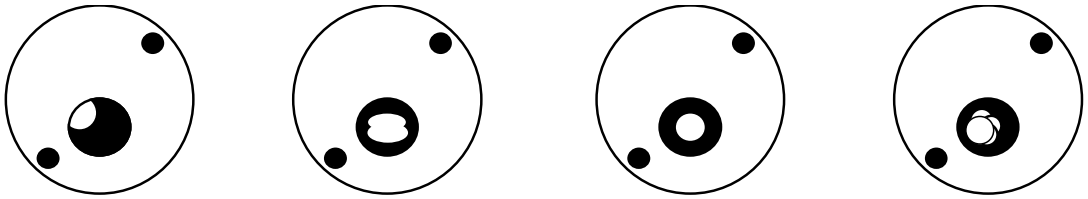
Holmium: Lamp Volts	800V	Ho/Nd:YAG:	Lamp Volts	800V
Lamp energy	50J		Lamp Current	50A
Repetition Rate	5 Hz		Repetition Rate	5 Hz

b. Use the test aperture to check the YAG channel centering into the second wedge optic opening. Examine the burn and proceed as follows:

NOTE:

• An acceptable burn is to be centered and clipping must not be seen. If the burn is acceptable, go on to step "b" below.

• An unacceptable burn will be well off center (more than a fourth of the burn is clipped). In this case, the second relay mirror must be adjusted to bring the YAG beam closer to the center of the aperture as described below.



Beam is clipping the 10mm burn aperature tool. Adjust plano relay mirror down and to the right to center the burn.

An oblong or small burn spot or distorted burn spots usually indicates that the cavity is not peaked or some of the cavity optics are damaged. Check HR, OC, and rod for burn spots.

The burn is round and centered in the aperature. The goal is to get all four channels centered, at the same time each beam is centered (peak signal) on the transimpedance detector.

All four burns are centered. The overall diameter of the burn is slightly larger than any one single burn. This is OK.

FIG. 3.7

Make a slight adjustment to the second relay mirror, then check the result by making a burn on photopaper at the second wedge optic. Because a number of burns may be required to complete the adjustment, using the test aperture can slow things down (the aperture would have to be reloaded with a clean piece of paper after each shot). As an alternative, find a second channel that is already centered in the aperture, and then use the service screen to turn that channel on as well as the channel to be adjusted. When the laser is fired the two channels will each fire in turn. Instead of using the aperture, make the burns on a larger piece of paper held in front of the aperture, moving to a clean spot for each check. The known good channel becomes the reference - adjust the second relay mirror for the channel out of adjustment until the burn footprints are on top of each other. Once the channel is roughly positioned over the aperture, lock down the mirror and go to step "c" below.

c. Set the system to the following repetition rate and align the YAG beam into the fiber port using the Fiber Alignment Detector Box (Transimpedance Amp).

Holmium: Repetition rate = 40 Hz
Nd:YAG: Repetition rate = 60 Hz

Insert the service attenuator into the beam path (SW4 on the CPU PCB to the left). Connect the fiber alignment detector box to the fiber port and oscilloscope. Select the proper repetition rate according to the type of system being worked on. Then adjust as indicated in the subparagraph below.

Fire the laser while observing the oscilloscope. Each laser pulse will produce a squarish pulse on the screen. Make slight adjustments to the channel first relay mirror to peak the amplitude of the pulses on the oscilloscope. Use the highest scope gain and adjust for the highest peak.

d. Check the burn at the second wedge optic using the test aperture.

The beam must be unclipped. If not, repeat steps "a" and "b" above until both pass with the adjustments mechanisms locked down.

e. Make a burn into the test aperture with all four channels turned on.

The resulting burn footprint should be circular in shape and contained in the aperture (no clipping).

f. Remove the service attenuator (SW4 on the CPU PCB to the right).

g. Perform the System Checkout as outlined in Topic 3.4

3.2.5 Pyro Detector Alignment

In order for the calibration of the system to be as accurate as possible, the pyro detector mirrors must be properly aligned. This alignment may also be required if the Optics Bench PCB is changed.

1. Set up of the laser.

a. Go into the service screen and enter the following parameters. Turn on one Holmium flashlamp and set the lamp energy at 50 Joules, lamp volts at 800V and repetition rate of 10 Hz.

b. Set the oscilloscope for 1V / Div. with sweep time of 200µS.

2. Align the pyro mirror.

a. Connect channel A from the oscilloscope to TP1 (MPREA) on the Optics Bench PCB. Use TP2 as ground.

b. Adjust the pyro mirror in both X-Y axis to peak the signal as seen on the scope.

3.2.6 Aiming Beam Alignment

The aiming beam can be adjusted by repositioning the aiming diode mount or by adjusting the position of the folding mirror (the mirror that directs the aiming beam onto the beam combiner). Observe the aiming beam output from the fiber and adjust to obtain a full spot of bright red light (no doughnut). Note: A faint halo is acceptable. Refer to Fig. 3.8.

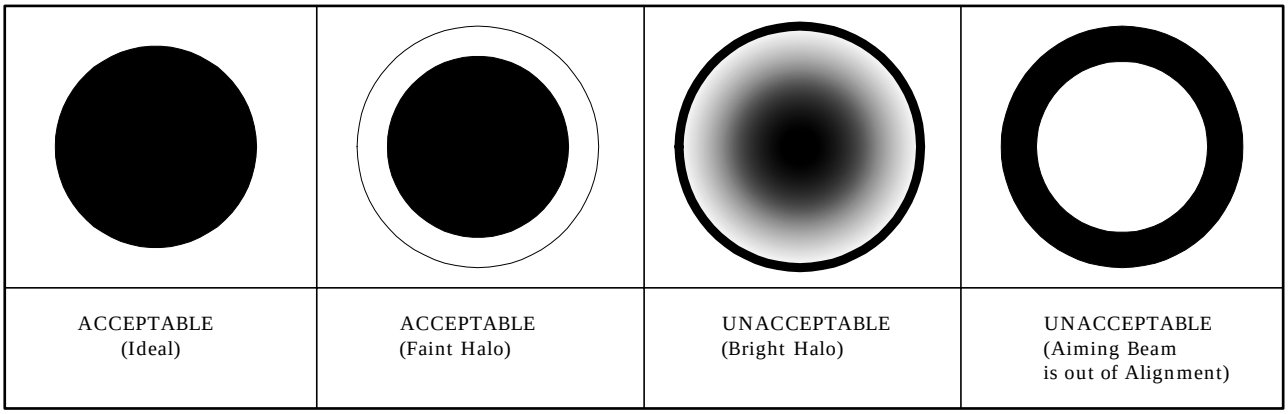


FIG. 3.8: AIMING BEAM PROFILE

3.3 ELECTRICAL ADJUSTMENTS

3.3.1 Voltage Configuration

The VersaPulse Select PowerSuite can be configured to operate with the AC mains voltage at 220VAC ±10% by setting various jumpers on the AC Control PCB. Refer to Figure 3.9 and the procedure below in configuring the AC Control PCB.

1. Set up

a. Measure the AC mains voltage and record on the Certification Report.

b. Verify the VersaPulse PowerSuite is not connected to the AC mains.

c. Open the front door and remove the right side cover. (Refer to Section 5).

2. Locate the AC Control PCB (behind the right side panel) and identify TB5 & TB2 (top of the AC Control PCB). Refer to Fig. 3.9.

3. Locate the large brown wire in TB5-1 and position the other end in TB2 as follows in Fig. 3.9:

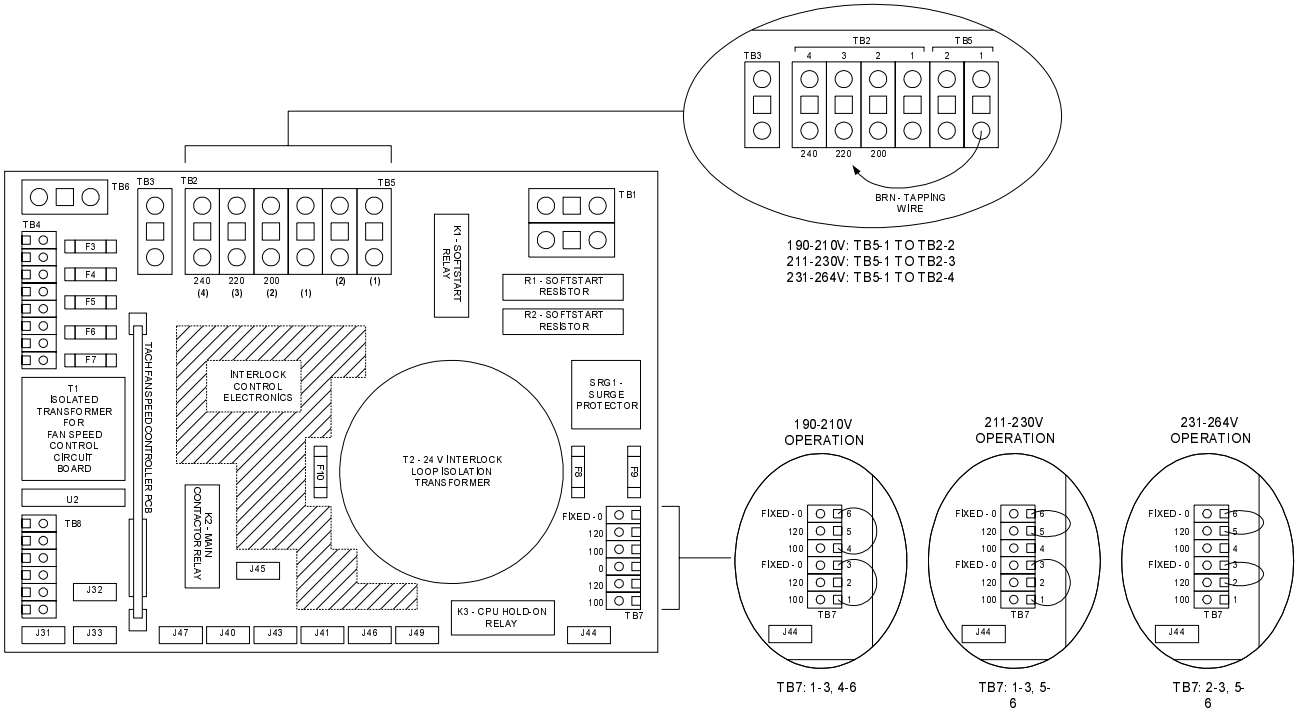


FIG. 3.9: AC CONFIGURATION ON THE AC CONTROL PCB

4. Locate the two small blue jumper wires in TB7 (bottom right). Position the jumpers as illustrated in Fig. 3.9.

5. Connect to system to the AC service.

CAUTION: Once connected to the site electrical service, lethal voltages are present inside the unit. The AC power is present at the circuit breaker, main contactor and isolation transformer. In addition, the isolation transformer secondary outputs are “hot”. Review and understand the safety subtopic in Section 5 before preceeding.

The system can be hard wired to electrical service, but ismore typically connected by a plug to an electrical outlet.

If the system can be hard wired, the customer must provide an electrician to wire the cord end into the electrical service outlet. A lockable electrical service disconnect switch must be installed if the system is hard wired.

If the system is to be plugged into an electrical receptacle, the appropriate receptacle should already be installed by the customer's electrican. The installing engineer connects the plug to the end of the VersaPulse Power Suite electrical cable.

3.3.2 Fan Speed Adjustment

The Fan Speed Controller PCB monitors and varies the speed of the fan in relation to the temperature of the coolant. As the coolant temperature rises above a specified temperature, the fan speed will increase to bring the temperature of the coolant to within a specified temperature range. When the temperature of the coolant is at the proper temperature level, the fan speed will also decrease in speed (idle). The fan speed is monitored by a Tachometer PCB.

1. **Disable system autocalibration (SW3 to the left on the Controller PCB).**

2. **Turn the system on and let the system complete the self-test start up routine.**

   Allow the laser to operate at idle (no firing) in a temperature stable environment for 5 minutes.

3. **Adjust R21 on the Fan Speed Controller PCB for -1.0 VDC as measured across TP5 and ground (TP7 or TP8).**

   NOTE: The Fan Speed Controller PCB is located on the AC Control PCB between the K2 relay and the T1 transformer.

4. **Insert the Service Attenuator (slide SW4 on the Controller PCB to the left) in the beam path and attach any test fiber.**

5. **Select the HIGHEST pulse rate in the User Mode and increase the pulse energy to maximum.**

6. **Fire the laser for a few minutes and verify that the fan speeds up when the voltage at TP5 reaches -2.0 VDC.**

7. **Stop firing and verify that the fan speed returns to idle speed and the voltage at TP5 returns to -1.0 VDC within a few minutes.**

8. Return the switches on the Controller PCB to their normal positions.

SW3 to the RIGHT (enable autocalibration)
SW4 to the RIGHT (Service Attenuator out of the beam path)

3.3.3 Speaker Volume Adjustment

The VersaPulse PowerSuite emits various tones by way of a speaker as the system receives inputs from the user, fires the laser or detects a fault condition. The volume of the tone can be raised or lowered by adjusting a potentiometer on the Controller PCB. Use the following procedure to raise or lower the speaker volume.

1. Locate R8 on the Controller PCB.

2. Alternating between the READY and STANDBY buttons on the touchscreen display,

3. Adjust R8 on the Controller PCB until the volume out of the speaker is about mid-range.

4. Close the front door and repeat step 2. Verify the speaker can be heard. If not, adjust R8 until the speaker can be heard (with the front door closed).

3.4 MECHANICAL ADJUSTMENTS

These procedures set the External Fiber Sense switch and the Blastshield Sense switch.

3.4.1 External Fiber Sense Switch Adjustment

Refer to Fig. 3.10 when performing the External Fiber Sense switch adjustment procedure.

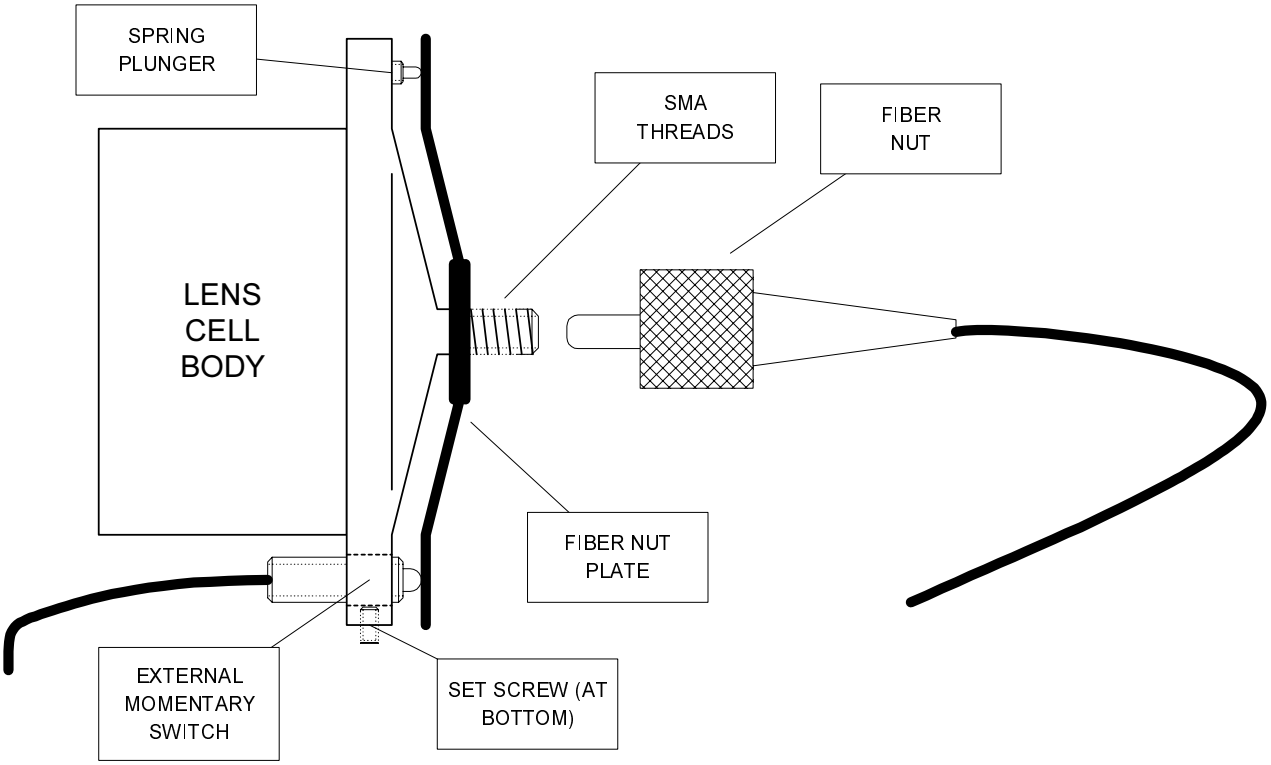


FIG. 3.10: SMA FIBER PORT ASSEMBLY

1. **Open the front door and locate LED12 on the Controller PCB or connect a DVM across TP51 (FBRIN) and TP46 (GND).**

2. **Connect a Coherent test fiber loosely onto the SMA port, but do not thread the nut fully on the SMA threads. Observe the LED12 or the DVM voltage.**

3. **Adjust the position of the Fiber Sense switch so that LED12 comes ON or TP51 on the DVM goes HIGH with approximately 1/4 to 1/2 turns before the nut is fully seated.**

NOTE:

- If LED12 comes ON *with 1/4 or less turns* to go before the fiber is fully threaded, remove the fiber, the fiber nut plate, and pull the Fiber Sense switch out of the lens cell body slightly and recheck.

- If LED12 comes ON with *more than 1/2 turns* to go before the fiber nut is fully threaded, push the external switch IN to the lens cell body slightly and recheck.

3.4.2 Blastshield Sense Switch Adjustment

Perform this procedure if the blast shield has been inserted and the INSERT DEBRIS SHIELD message remains ON. Refer to Fig. 3.11.

1. **Open the front door and remove the blastshield access door from the front door; locate LED11 on the Controller PCB or connect a DVM across TP50 (BLST) and TP46 (GND).**

2. **Reach around the right side of the laser head casting and locate the blastshield; remove the blastshield.**

3. **Adjust the blastshield switch.**

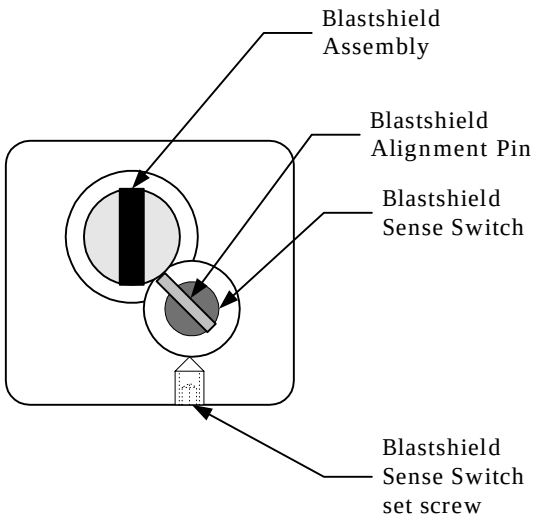


FIG. 3.11: BLASTSHIELD SENSE SWITCH

The blastshield switch is located behind the blastshield alignment pin. Loosen the set screw securing the blastshield sensing switch and adjust the switch so that LED11 comes ON or TP50 goes HIGH on the DVM just before the blastshield is fully seated in the detent.

a. If LED11 comes ON with more than 2mm of travel before the blastshield snaps into the detent, loosen the set screw and slightly push the blastshield switch IN to the casting and recheck.

b. If LED 11 does not come ON or intermittently comes ON when in the detent position, loosen the set screw and pull the blastshield switch OUT of the laser head casting and recheck.

3.5 ENERGY MONITOR AND AUTO CALIBRATION

The energy monitor calibration procedure adjusts energy monitor amplifier circuit gains to establish a conversion factor in terms of Volts / Joule by referencing delivered Holmium and Nd:YAG laser energy as measured on a calibrated external power meter. The optical calibration procedure determines optical transmission characteristics of an intra-beam attenuator optic for Holmium wavelength (Ho & Nd of a dual wavelength system) and if the laser is a dual wavelength system, the procedure determines the reflectivity characteristics of the pick-off mirrors for the Neodymium wavelength. Then at each system turn-on cycle, the software executes an automatic laser calibration (autocal) which allows the computer to determine and store (in NVRAM) the flashlamp drive parameters required to generate minimum and maximum pulse energies for each installed laser channel.

NOTE: All Laser Safety procedures must be followed while performing this procedure (i.e., safety glasses / goggles must be worn).

1. Set up.

a. Open the front door and remove the top (external) cover including the inside laser head cover.

b. Disable the AUTOCALIBRATION by moving the calibration switch (SW3) on the Controller PCB to the left.

2. Turn the laser on.

3. Access SERVICE MODE by moving sliding the service switch (SW2) on the Controller PCB to the left.

4. Initialize the NVRAM.

On the first service screen, depress the INIT NVRAM button and hold until the second tone is heard. This clears and initializes the battery back-up memory, then loads the default values.

5. Set the laser to the following parameters:

a.

Voltage	800V
Pulse Rate	10 Hz
Lamp Energy	45J

b. Turn on the first laser channel (all other laser channels should be OFF).

6. Attach a Power Calibration Fiber (P/N 0623-973-01) and turn ON the aiming laser.

Direct the fiber output toward the external power meter. The aiming beam should approximately 10mm in diameter.

7. Place the laser in READY mode.

8. Depress the footswitch and fire the laser.

Adjust the LAMP ENERGY until 6 Watts is delivered out of the fiber.

9. Setting the Differential and Gain amplifiers.

a. Attach oscilloscope probes to TP15 (SDIF) and GND on the Controller PCB, and adjust potentiometer SGAIN (R4) on the Optics Bench PCB until the signal amplitude is 4.0 ±0.1 VDC.

b. Move the oscilloscope to probes to TP24 (MNDIF) and GND on the Controller PCB, and adjust potentiometer MGAIN (R3) on the Optics Bench PCB until the amplitude is 4.0 ±0.1 VDC.

10. Depress the footswitch and adjust the LAMP ENERGY until 10 Watts is delivered. Verify pulse rate is at 10 Hz.

NOTE: 10 Watts ÷10 Hz = 1 Joule Pulse

11. Preparing the main and safety energy channels.

a Attach a DVM to TP38 and GND on the Controller PCB.

b. Fire the laser and adjust the potentiometer MAIN 2.1 (R32) on the Controller PCB until 1.0 ±0.02 VDC is measured on the DVM (1V / Joule).

c. Move the DVM probes to TP36 and TP38 and fire the laser.

d. Adjust the potentiometer SAFE 2.1 (R15) on the Controller PCB until 0.00 ±0.02 VDC is measured on the DVM.

(If the laser is a Dual Wavelength system, proceed with the following steps, otherwise, skip to step 19).

12. Set the laser to the following parameters:

Turn lamps 1, 3, & 4 off, and turn lamp 2 on.

a.

Voltage	800V
Pulse Rate	50 Hz
Lamp Current	65 Amps

b. Verify laser channel #2 is ON and all other laser channels are OFF.

13. Depress the footswitch and adjust the LAMP CURRENT until 50 Watts is delivered.

NOTE: 50 Watts ÷50 Hz = 1 Joule Pulse

14. Preparing the main and safety channels.

a.Attach the DVM probes to TP36 and GND on the Controller PCB and fire the laser.

b. Adjust the potentiometer MAIN 1064 (R34) on the Controller PCB until 1.0 ±0.02 VDC is measured (1 Volt / Joule).

c. Move the DVM probes to TP36 and TPTP38 on the Controller PCB and fire the laser.

d. Adjust the potentiometer SAFE 1064 (R61) on the Controller PCB until 0.00 ±0.02 VDC is measured.

15. Turn all lamps on and place the laser into READY, then press the CALIBRATE button until the second tone is heard.

NOTE: Depressing the footswitch is not required.

16. Enable the AUTOCALIBRATION by sliding the calibration switch on the Controller PCB SW3 to the right and turn the laser OFF.

17. Disconnect the test equipment probes from the laser, install the covers and close the front door. Turn the laser on.

3.6 SYSTEM OPTIMIZATION CHECK

This section verifies the VersaPulse PowerSuite is operating in an optimal condition after the optical alignment procedures and all the calibration procedures have been completed.

3.6.1 Fiber Alignment Test

This system check out confirms that the laser is functioning correctly.

1. Open the front door turn the system on and allow it to go through auto calibration. After auto calibration is completed, place the system in service mode.

2. Check the fiber focus alignment using a test fiber.

If the system passes auto calibration and the channel performance appears normal, check for proper alignment of the beam into the fiber. This is done using a special test fiber (P / N 0621-675-01). The fiber proximal end is coated with a red ink (Berol 8800 red marker) that records an impression of the YAG beam footprint where it enters the end of the fiber. The laser is fired into the test fiber, then the fiber end is examined using a hand held 100X microscope. A good alignment will result in a “concentric” footprint, (i.e., the footprint will be approximately centered in the fiber core and be well away

from the cladding that surrounds the fiber). For dual wavelength systems, two fiber burns must be done.

a. Install a test fiber in the 100X fiber examination microscope and examine its surface to confirm that it is unused.

b. Install the test fiber at the fiber port, then turn on the system and go to service mode.

c. Turn on the flash lamps.

Holmium - Turn on all the flashlamps and set the lamp energy at 50 Joules, lamp volts at 800V and a pulse rate of 2 Hz.

Ho / Nd:YAG - Two fiber burns must be done.

1) Holmium: Turn on all flashlamps except lamp #2 and set the lamp energy at 50 Joules, lamp volts 800V and a pulse rate of 5 Hz.

2) Nd:YAG: Turn off all flashlamps except Lamp #2, set the lamp current at 75A, pulse rate at 60 Hz and lamp volts at 800V.

NOTE: The lamp volts is always set at 800V.

d. Fire the laser for approximately one second.

e. Remove the fiber and examine in the microscope. The burn and cladding will be easily visualized if the other end of the test fiber is pointed towards a light source. The burn should be approximately centered in the fiber optic and be well away from the contact with the fiber cladding, a shown in the drawing below. If the system fails its check, perform the YAG Channel Adjustments in Topic 3.5.

NOTE: If the spot size is large, check the individual YAG channels for proper alignment. Spot size should be less than 260µm in diameter and no closer than 50µm from the cladding.

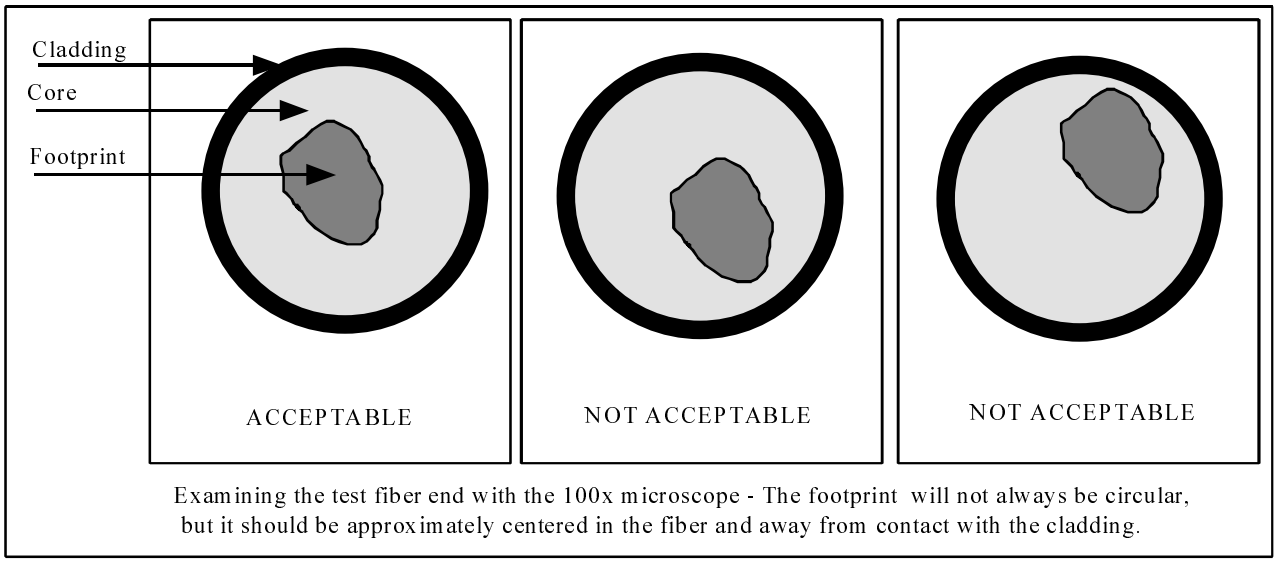

Cladding
Core
Footprint
ACCEPTABLE
NOT ACCEPTABLE
NOT ACCEPTABLE
Examining the test fiber end with the 100x microscope - The footprint will not always be circular, but it should be approximately centered in the fiber and away from contact with the cladding.

FIG. 3.12: EXAMINING THE TEST FIBER BURN

f. Clean the residual ink from the fiber port & debris shield with a Q-tip.

3. Confirm the calibration. See Section 3.4.

Use the test fiber (0623-973-01) and direct towards the FSH head.

3.6.2 Verify Calibration - Delivered Power Out of the Fiber

Turn the laser on and allow the system to perform the auto calibration, then verify the power calibration for each wavelength at each operating point in this topic section. All delivered powers must be within ±10% of requested power.

1. Enable the "autocal" function by setting SW3 on the Controller PCB in the left position. Close the front door and turn the laser on.

Wait for the User screen to be displayed and ensure that no calibration error messages are displayed.

2. Attach a known good Power Calibration Test Fiber (P/N 0623-973-01) to the fiber port and turn the aiming laser on. Direct the distal end of the fiber towards a calibrated power meter.

The aiming beam diameter on the detector surface should be approximately 1 cm in diameter.

3. Fire the laser.

(For Holmium wavelength)

Test the output at all combinations of low, medium, and high pulse energies and repetition rates. The delivered power must be within ±10% of indicated (requested) power.

(For Neodymium Wavelength)

Test the output in continuous exposure mode and at low, medium and high average powers. The delivered power must be within ±10% of indicated (requested) power.

4. Remove the test fiber.

3.6.3 Flashlamp Performance Check

1. Check rod calibration values.

In order to verify that the system is properly aligned, perform the following:

- For Ho:YAG and Ho/Nd:YAG - Go to the second service screen and depress the PLOT CAL button (this will take you to the ENERGY CALIBRATION PLOT screen, which is the fifth service screen). Note the lamp energy for Holmium and lamp current for Neodymium values for each of the four channels. In lamp energy, it should achieve 3.5 Joules and in lamp current, it should achieve 100 Watts.

- For Ho:YAG - If the 3.5 Joule lamp energy is greater than 160J, replace the lamp.

- For Nd:YAG - If the high point current is greater than 92A, replace the flashlamp.

- If the system has failed auto calibration or the YAG channel performance appears poor, adjust cavity optics as necessary to lower values to acceptable levels and perform the YAG Channel Adjustments in Topic 3.4. If necessary, re-lamp the cavity.

a. Fire the laser in user mode @ 5 Hz, 0.5J for 10 seconds and go the service mode.

b. Examine the graph in the fourth service screen.

Each individual laser must reach the 20% line by its second shot. If any of the laser cavities do not, the alignment of that particular cavity may need peaking. Also, check the mode burns at this point. Note that even if the burn may look good, the cavity may need peaking.

NOTE: It is permitted for the first shot of each cavity to fall below 20% line on the graph.

c. Repeat step b above with the laser set at each of the following operating points:

5 Hz (or maximum available), 0.5J
5 Hz, 3.5J
40 Hz, 2J (for 80W systems) or 30 Hz, 2.7J (80 / 100 systems)

2. Inspect debris shield and clean/replace as required.

3.7 OPERATIONAL AND SAFETY CHECKOUT

CAUTION: The operational tests include firing the system and attempts to fire the system with one disabling condition. Select a low power setting and direct the test fiber output into a calibrated power meter.

Attach a test fiber and verify the remote interlock plug and footswitch is connected, then check the system operation as follows:

1. Check the circuit breaker.

a. Connect the system to the AC power source and turn OFF the circuit breaker. Verify there is no AC voltage present at.

b. Turn ON the circuit breaker and verify there is Ac voltage present at

2. Check the keyswitch.

a. Rotate the keyswitch to the II (start) position; hold for one second and release the key. Upon release, the spring-loaded key rotates to the I (on) position. Verify the system turns on proceeds with the self-test routine and the key cannot be removed from the keyswitch.

b. Rotate the key to the ⏻ (off) position and verify the system turns off.

3. Check the E-Stop button.

a. Depress the E-Stop button and verify the system is deactivated.

b. Turn the laser back on and verify the system goes through the self-test routine.

4. Check the BRH plug.

a. Unplug the BRH plug and verify the “REMOTE INTERLOCK” message appears on the display and the system goes to STANDBY.

b. Depress the footswitch and verify the system is unable to fire.

c. Reconnect the BRH plug into the system and verify the “REMOTE INTERLOCK” message goes away, then place the system into READY.

5. Check the blastshield.

a. Remove the blastshield and verify the “INSTALL DEBRIS SHIELD” message appears on the display and the system goes to STANDBY.

b. Depress the footswitch and verify the system is unable to fire.

c. Reinsert the blastshield and verify the “INSTALL DEBRIS SHIELD” message goes away, then place the system into READY.

6. Check the fiber switch.

a. Loosen the fiber from the fiber port and verify the “ATTACH FIBER” message appears on the display, then verify the system goes to STANDBY.

b. Depress the footswitch and verify the system is unable to fire.

c. Tighten the fiber and verify the “ATTACH FIBER” message goes away. Place the system into READY and verify that the aiming beam is visible at the end of the fiber output. Also verify that the aiming beam intensity properly responds to the touch screen intensity control.

7. Check the flowswitch.

a. Turn the system off and disconnect the connector (J49) on the AC Control PCB. Connect and ohmmeter across the connector. The ohmmeter should read infinite ohms.

b. Turn the laser on and hold the key in the II position. The ohmmeter should read zero ohms.

8. Check the Footswitch.

a. Unplug the footswitch and verify the "ATTACH FOOTSWITCH" message is displayed and the system goes to STANDBY.

b. Reconnect the footswitch into the system and verify the "ATTACH FOOTSWITCH" message goes away, then place the system into READY.

c. Depress the footswitch and verify the system fires.

NOTE: On Ho/Nd:YAG systems, confirm that the "DUAL FOOTSWITCH" message is displayed when the footswitch is disconnected.

9. Check the LCD color display.

a. Verify the LCD color display is operating properly.

b. Verify the LCD color display inputs are functional.

c. Verify the aiming beam responds to OFF, LOW, MEDIUM and HIGH settings.

d. Fire into the power meter for several seconds, noting the power reading on the power meter. Confirm that the total energy display value has incremented, then confirm that the value clears back to zero when RESET is depressed.

10. Check the Remote control Panel.

The Remote Control Panel comes as an option on the Ho & Ho/Nd:YAG versions of the VersaPulse PowerSuite lasers. If the laser has a Remote Control Panel, perform the following procedure and confirm the proper operation of the Remote Control Panel

a. Connect the Remote Control Panel to the connector at the rear of the system.

b. Verify the system is able to receive operator inputs by depressing the LCD display.

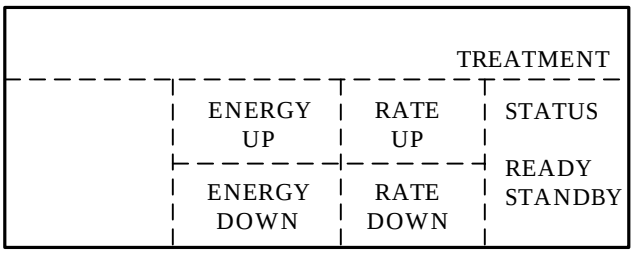


FIG. 3.13: REMOTE CONTROL DISPLAY (Holmium Only)

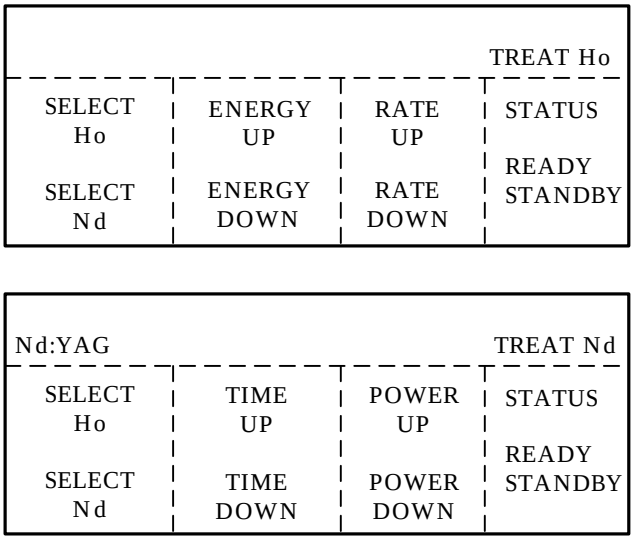


FIG. 3.14: REMOTE CONTROL DISPLAY (Ho & Ho/Nd:YAG Only)

3.8 PERIODIC MAINTENANCE REQUIREMENT

The systems require the following periodic maintenance:

ANNUALLY (AS REQUIRED):

Perform a general visual inspection of the electrical, mechanical, and optical components.

Check / clean the air filter. The air filter is mounted on the bottom of the system, held in place by a removable bracket. A dirty filter should be cleaned (vacuum) or replaced if damaged.

Replace the DI cartridge after 12 months of use, or when the system has coolant conductivity faults (resistivity ≤ 250 kΩ).

Check / replace the coolant particulate filter. Replace the filter when it is visibly discolored.

Check the blastshield optic and replace if required.

Cooling system level check. The cooling system fill reservoir is located on the top of the laser. The top cover must be removed in order to gain access to the reservoir. Use distilled water, with the system running, to bring the coolant level up to half full in the fill reservoir. Cycle the system off / on several times, adding deionized water as necessary until the level stays up.

Verify Calibration per Section 3.6.2

- If the high lamp energy exceeds 160J for Holmium or 92A of lamp current for the Nd:YAG, replace the flashlamps as required.
- Check alignment to the fiber with all bricks turned on. See Section 3.2.
- Check quality and intensity of aiming beam through the fiber.
- Perform the Operational and Safety Checkout (see Section 3.7).

4.0 THEORY OF OPERATION

4.1 INTRODUCTION

4.1.1 Operational Overview

The VersaPulse® PowerSuite™ YAG laser system is designed for use in multi-specialty surgical applications. Depending upon the model, the treatment laser delivers pulsed 1064 nm or 2120nm wavelength energy (invisible) through a user attached delivery fiber in response to the depression of an attached footswitch. The pulses continue until the footswitch is released. A diode laser provides a visible (red, 650 nm) aiming beam. An equipment description, specifications and detailed user operating instructions are included in the VersaPulse PowerSuite Operator Manual.

A key is required to turn the system on. At turn-on the system undergoes a series of self tests (*approximately 40 seconds*), then, if no malfunctions are detected during the self tests, goes to its STANDBY condition. If the self testing process detects any malfunction, an error message or fault code will be displayed and the system will not be enabled until the fault condition clears.

Once the unit is in STANDBY the user selects the desired operating parameters through an LCD color display. Controls include aiming beam intensity, wavelength selection (for dual wavelength models only), pulse energy, pulse rate, and pulse width. Selections are displayed on the LCD color display.

Aiming beam intensity can be turned off or adjusted for high, low or medium.

Pulse energy and pulse rate combine to determine the average power.

(ENERGY / PULSE)*(PULSES / SECOND) = Average Power in Watts

Holmium:

Pulse energy is adjustable in increments from 0.2 to 3.5 Joules. Pulse rate is adjustable in increments from 5 to 50 Hz. The combination of pulse energy and pulse rate define an *operating point.* Not all combinations of pulse energy and pulse rate are valid, and the operating points available vary with the different VersaPulse PowerSuite models available. Consult the Operator Manual for detailed information on the operating points for a particular model.

Nd:YAG :

Pulse energy is adjustable in power increments from 5 to 100W. Pulse rate is usually 60 Hz. The combination of pulse energy and pulse rate define an *operating point*.

A total energy display with a *clear* function allows the user to keep track of the total energy used from the last time the display was cleared.

A delivery system fiber is attached to a fiber port on the front of the system console. The delivery fiber comes in a number of styles to meet the requirements of various applications (angled, etc.). The system will not fire without a delivery fiber attached.

Once the system operating parameters are selected, the user selects the READY mode, positions the fiber output at the treatment site, then depresses the footswitch to deliver treatment pulses at the rate and energy selected. The treatment delivery will continue until the footswitch is released. The shutter opens and treatment delivery begins without delay.

Fault monitoring continues for as long as the system is turned on, and any detected fault is reported on the LCD color display.

An emergency off button is located on the console next to the key switch. Depressing it will turn the system off. The system may also be turned off by moving the key to the off position or by turning the main breaker off.

NOTE: The "OFF" position is illustrated by this icon

4.1.2 Functional Overview

The VersaPulse Powersuite can hold up to four YAG rods. The maximum average power and wavelength(s) the system provides is determined by the number and type of rods used.

Refer to the VersaPulse Powersuite Block Diagram in Section 8 page 8-3. The VersaPulse PowerSuite has four identical YAG cavities arranged in a 2x2 matrix. Each cavity includes its own rod, flash lamp, high reflector, output coupler and a set of two relay mirrors. The rods are operated sequentially - never together - thus each rod is capable of producing the maximum selectable pulse energy. Each rod delivers every fourth pulse. This sequential firing allows the VersaPulse Powersuite to provide four times the pulse rate as could be provided by a single rod, increasing the maximum average power available by the same factor (four).

For example, at the 40 Hz pulse rate, each rod is operating at 10 Hz, and is producing 1/4th of the average power. As a result, the VersaPulse PowerSuite laser provides higher selectable pulse rates and higher average

powers without requiring the extreme rod cooling as would be required in a single rod system at the same operating point.

The use of multiple heads results in a number of advantages over previous surgical solid state lasers: VersaPulse PowerSuite is smaller and lighter; it has a much simpler and more reliable cooling system; and it can operate at much higher pulse rates, resulting in higher average powers. Also, different rods and optics can be installed enabling a multiwavelength laser is one package.

While the use of multiple heads provides all the above mentioned user advantages, it also results in several design challenges:

- Flash lamp supply switching - The VersaPulse PowerSuite uses a combination of capacitor storage and rectified AC voltage to supply the current required to turn on the flash lamps. The lamp current, pulse width, and voltage level of the charge on the capacitor determines the amount of light energy out of the lamp, and therefore, the pulse energy out of the rod. Using four heads requires a method of switching the reservoir capacitor bank voltage between the four flash lamps. The VersaPulse PowerSuite uses Insulated Gated Bipolar Transistors (IGBT) to switch the reservoir capacitor bank voltage between the four heads.

- Multiplexing the beams - Merging the four YAG beam paths requires a more complicated optical scheme. The VersaPulse PowerSuite Holmium and the VersaPulse PowerSuite Ho/Nd:YAG use a servo positioned rotating mirror to assemble the four YAG beams into a single beam. The servo system must reposition the mirror between pulses, pointing the mirror towards the head that will be flashed.

- Control - In general, the microprocessing demands of the VersaPulse PowerSuite are greater than that of a single head system. The VersaPulse PowerSuite uses a Motorola 68000 microprocessor.

For the purposes of this discussion, the VersaPulse PowerSuite laser is divided into the following functional subsystems. The remaining topics in this section provide a detailed description of each subsystem.

Power Switching, Conditioning, Distribution (4.2) - Provides switching and conditioning of the primary power input, converts the AC line voltage to DC voltages used within the system and distributes the various voltages throughout. It includes the turn-on and turn-off circuitry. It does not include the high voltage power supply.

Cooling (4.3) - The cooling system removes heat from the YAG cavities and two beam dumps. It is a closed loop distilled water system including a pump, reservoir tank, fill tank, heat exchanger, variable speed fan, D/I filter, particle filter, flow switch, temperature sensor and resistivity sensor.

Control Electronics (4.4) - The control electronics executes the software instructions to provide overall control to the VersaPulse PowerSuite laser. It includes a microprocessor, Eraseable Programmable Logic and its associated circuits (DIO, ADC, DAC), LCD color display, and a number of electronic and electro-mechanical devices.

Flash Lamp Supply Circuits (4.5) - The flash lamp supply starts and simmers the four flash lamps, responds to control electronics commands to charge the capacitor bank and discharge the capacitor bank through the selected flash lamp. It includes the capacitor bank, IGBT driver circuitry, flash lamp select IGBT's, starter transformer, flash lamps and simmer / start controller.

The flash lamps are simmered at a low current ≈150mA between flashes (the rods are not simmered - the flash lamps are kept on in order to allow instantaneous IGBT turn on). The simmer circuitry provides the simmer current to each of the four lamps and supplies a transformer used to generate a starter pulse to ionize the flash lamps.

The YAG pulses of laser energy are controlled by command signals from the control electronics. Prior to each pulse the control electronics sends a set of parameters to the HVPS. The parameters will set the following:

- Lamp volts
- Lamp current / energy
- Pulse width

The HVPS will then charge the capacitor bank to the indicated voltage. To get a pulse of treatment energy the control electronics triggers the IGBT for the cavity that has been selected for firing. The IGBT turn-on creates a discharge path for the capacitor bank through the selected flash lamp.

Optics (4.6) - The optics include the portions of the system that operate on the YAG beams and / or diode aiming beam. There are four separate and identical YAG cavities arranged in a 2 x 2 matrix. Each includes a rod, flash lamp, high reflector, output coupler, and two relay mirrors. The first relay mirror direct the YAG output from the OC towards the surface of the plano relay mirror. It is then reflected onto the galvo or servo positioning mirror. The galvo (servo) positioning mirror is used to multiplex the four separate YAG beams into a single beam path. The remainder of the beam path includes the following optical components.

Folding Mirrors - Two folding mirrors direct the beam output from the galvo (servo) mirror through the center wall towards the fiber focusing lens.

Low Energy (LE) Attenuator - The LE attenuator is inserted into the beam path to allow the VersaPulse PowerSuite to deliver a lower range of pulse energies. This function is currently used on the VersaPulse PowerSuite dual wavelength lasers (if Holmium energy is less than 0.5J or Neodymium power less than 25 W is selected). Reflected energy is directed into a water cooled beam dump.

Wedge Optic - A wedge optic is required to check the power after the LE attenuator. Two samples are reflected off the wedge. An imaging mirror directs the sample toward two pyrodetectors mounted on the Optics Bench PCB (TP1 & 4). The pyro circuitry translates the energy sample current into a voltage proportional to the energy of the YAG pulse.

Service Attenuator - The service attenuator is inserted into the beam path to attenuate the beam before it enters the fiber focus assembly. This prevents damage to the attached fiber alignment detector as the system is fired to do the fiber focus alignment. It is operated by SW4 on the Controller PCB inside the unit accessible to the service engineer. The system will operate in user mode if the service attenuator is left in the beam path, although less than 1% of pulse energy will exit the laser making the laser unusable. Reflected energy is directed into a water cooled beam dump.

Safety Shutter - Blocks the treatment beam path when de-energized.

If the laser is fired with safety shutter closed (during autocal), all energy is directed into a water cooled beam dump.

Aiming Beam Diode, Folding Mirror, and Combiner Optic - Aiming beam is provided by a 650 nm diode laser. The user can select high, low, or medium intensity; or turn the aiming beam off. The folding mirror and combiner are adjusted to place the aiming beam coaxial with treatment beam.

Fiber Focus Lens - Focuses the beam into the end of the fiber to approximately 260µm diameter spot.

Blast Shield - Protects the fiber focus lens from debris ejected from the proximal end of the fiber in the event of a fiber failure.

Delivery Fiber - A number of delivery fibers are available for use with the VersaPulse PowerSuite, each providing features suiting it to certain applications, such as orthopedic, endoscope, laparoscope, laser assisted disk surgery, etc.. Most fibers are designed for a single use and are not reusable.

Software (4.7) - Software instructions are provided for the microprocessor to operate the system in response to user inputs. It also provides instructions for the firmware (i.e., EPLDs) in the monitoring and responding to any potential unsafe condition. The software is stored in an EPROM and in the EPLDs on the Controller PCB. Software upgrades can be accomplished by replacing the software EPROM and / or reprogramming the EPLDs. Different EPLD versions are required for different VersaPulse Powersuite models.

System configuration (i.e., max. power, wavelength, and etc.) are determined by the EPLDs.

4.2 POWER SWITCHING, CONDITIONING, DISTRIBUTION

Refer to schematic 8-7 in Section 8.

4.2.1 Input Power

The VersaPulse PowerSuite operates off of 200, 208 or 230 VAC ±10% @ 30A (32A for 100W Holmium) 50/60 Hz line voltage. The main circuit breaker is rated at 32 amps for 200, 208 or 230 VAC operation. The mains are wired into the circuit breaker. From the circuit breaker, the two mains run through the line filter and to TB1 on the AC Control PCB. A surge protection device SRG1 is connected across the mains at J42. With the mains connected to the AC Control PCB, power is directed in paralled to the following areas of the AC Control PCB:

- 24 VAC Interlock Transformer (T2).
- Start/Run/Stop Circuit.
- Through either softstart resistors, R1 & R2 or main contactor K4.

4.2.2 Power Distribution

All power from the main isolation transformer secondary is directed in parallel through the fuses (except to the high voltage power supply), then to the individual loads. The loads consist of the following:

- F3 - High voltage power supply (HVPS) auxilliary transformer.
- F5 - The water pump motor.
- F6 - A DC low voltage power supply (LVPS) for the operation of the microprocessor, LCD color display and all other electromechanical devices.
- F7 - Fan Speed Controller PCB and fan motor.

4.2.4 Turn On

The following sections describe the sequence of events starting from the time the system circuit breaker is turned on to the completion of the self-test routine after the keyswitch is set to the run position.

4.2.4.1 Circuit Breaker On, Keyswitch Off

The 24 VAC Interlock Transformer T2 is energized and supplies 24 VAC through F10, R13 and LED2, turning on LED2. The 24 VAC is also applied through the E-STOP switch to R14, illuminating LED4 and the main transformer thermostat to R15, illuminating LED5. If the key is left in the OFF position, current cannot flow through SW2, preventing LED6 from illuminating.

4.2.4.2 Turn On Sequence

As the key is rotated passed the ON (center) position, current flows through SW2, R16 and LED6, illuminating LED6. As the keyswitch continues to rotate to the START (right) position, SW1 closes, allowing current (KEYSTART) to flow to the bridge rectifier BR1, the common contact of the Main Contactor Control Relay K2, R17 and LED7, illuminating LED7.

The 24 VAC is converted to a full-wave rectified signal by BR1 and becomes the input to the +12 VDC voltage regulator VR1, rapidly charging C6 to +12 VDC (C+12V) with respect to C-. The C+12V becomes the supply voltage to the following to the following loads:

- The coil of the Main Contactor Control relay K2.
- The softstart relay K1.

Initially C5 is discharged and Q1 turns on energizing K1 for 200ms (LED1 illuminates) directing the mains current through the softsart resistors R1 & R2, K1 relay contacts and the primary side of the Main Isolation Transformer.

C4 begins to charge and after 100ms, Q2 turns on and provides a current path from C+12V through K2 and LED3 to C-, energizing the Main Contactor Control relayK2 and illuminating LED3. As K2 turns on, the 24 VAC is directed through the Main Contactor Control relay K2 to the coil of the Main Contactor K4, closing the Main Contactor. 24 VAC is also routed through the Main Contactor auxiliary contacts and directed to the CPU Holding Relay K3 and to the HVPS Interlock Circuit on J47.

When C5 is fully charged, Q1 turns off which disengages the softstart resistors. With full current available to the Main Isolation Transformer, the secondary loads turn on, which also turns on the LVPS. If the CPU is functioning properly, it will close the K3 relay by way of the CPU interlock inputs on J44. With K4 and K3 energized, the 24 VAC loop is latched on.

4.2.5 Shutdown

Under normal circumstances, the system remains on until one of the following events occur:

- Keyswitch moved to OFF position
- Emergency Off button pressed
- Turn off or trip of main circuit breaker
- Blown F6, F8, F9 or F10 fuses
- Software (CPU Controller) turns off K3)
- LVPS +5 VDC output shorted
- Loss of facility power
- Open Main isolation Transformer thermal switch
- A relay, contactor, connector or wire fails or opens.

4.2.6 Low Voltage Power Supplies

Refer to 8-5. A vendor supplied low voltage power supply provides +5 VDC, ±15 VDC, and +24 VDC for use throughout the system. The 220 VAC from the secondary of T1 is the supply voltage for the LVPS. A 250V 5 amp fuse is mounted on the power supply. The 5 VDC, ±15 VDC and 24 VDC lines are routed to the CPU PCB.

NOTE: The 24 VDC is routed to the CPU PCB and Shutter PCB.

The +5 VDC supply from the CPU PCB is also routed out to the LCD color display, and Shutter PCB.

4.3 COOLING

Refer to the Coolant System Simplified Diagram (Fig 4.1). As the lamps in the laser head are flashed, heat energy is produced in the flash lamps, rods, and housings. The cooling system transfers the heat energy from the flash lamp, rod and housings to the outside air. It utilizes a closed loop, forced air heat exchanger which contains approximately 2.5 gallons of distilled water. A speed controlled fan forces air through the heat exchanger. The cooling system also provides cooling for the two beam dumps. Note that the system does not contain an active chiller, therefore, the water can never be colder than ambient temperature during normal operation.

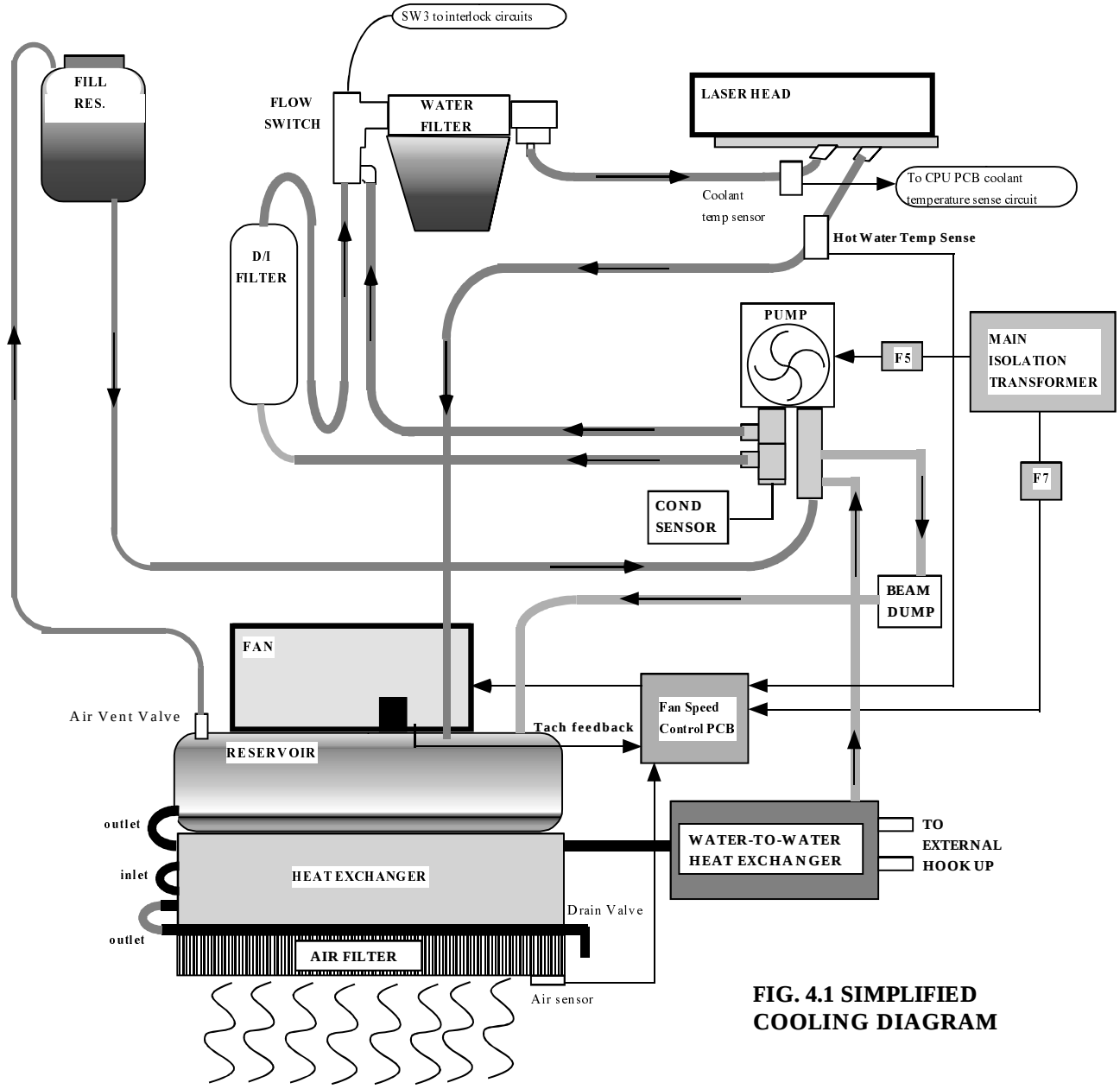


FIG. 4.1 SIMPLIFIED COOLING DIAGRAM

Refer to 8-12 in Section 8. Coolant resistivity and temperature are monitored by sensors that report an analog voltage to the microprocessor ADC circuit. The software checks the coolant resistivity and temperature at regular intervals in the following manner:

- The coolant is nonconductive (deionized) to minimize galvanic corrosion and high voltage arcing in the cooling loop. It is monitored by a probe and the signal amplified (WATERRESIST) in order to be read by the CPU. It will disable the system if the resistivity exceeds software limits. A message "CHECK FILTER" will appear on the LCD display. Note that the conductivity is effected by the action of the D/I filter. If the resistivity is low, running the system in its standby condition will allow water circulation through the D/I filter, eventually raising the resistivity to an acceptable level. Resistivity will tend to be lower when the unit is first turned on, then increase as the D/I filter removes charged particles. The D/I filter is a consumable item, and should be changed annually, or sooner if coolant resistivity problems occur.

  A 100Hz output signal (RESIST_100HZ_CLK/FSCLK) from the Digital Input/Output EPLD U39 leaves the Controller PCB at J9-5 and is routed to the resistivity sensor where the signal is applied across a one cm gap in the coolant. The other side of the one cm gap is sensed at J9-6 (CONDIN), and input to the transimpedance amplifier U29-2. the output of the U29-1 consists of positive and negative pulses. The individual pulses are selected for input to the positive and negative inputs of U27 by the action of U33 as driven by the polarity of the RESIST_100HZ_CLK signal. The output of U27-6 (TP34) as measured in volts, represents resistivity, where

  Resistivity = (1/Voltage @ TP34) 10^6 (e.g. 1/2 Volts = .5 X 10^6 = 500kΩ)

- The software checks the coolant temperature (WATER_TEMP) at regular intervals, providing overtemperature disable ("OVERHEATING" displayed on the LCD color display) when the coolant temperature reaches a set point. The disable clears when coolant temperature falls to a reset point. Note that for every 1• C rise in water temperture is equivalent to a .1V rise in output. Therefore the following table would apply:

Table 1: Water Temperature Circuit

Volts	Celsius
0.0 V	0• C
0.1 V	1• C
1.0 V	10• C
2.0 V	20• C
5.0 V	50• C

Set Point for the Ho:YAG & Ho/Nd:YAG = 60• C, Reset Point = 55• C.

Coolant flow is monitored by a flowswitch as a part of the CPU hold circuit to the main contactor. If flow is not sufficient, the system will not latch on and if already started it will shut off.

The coolant pump operates continuously and at a constant speed from turn on to turn off. It circulates the coolant through the closed loop. *The coolant pump must never be run dry.* A fan drives air over the heat exchanger. Fan speed is controlled by the Fan Speed Controller PCB.

The Differential Fan Speed Controller uses a tachometer feedback (monitoring the speed of the fan) to control the speed of the fan. The fan speed is controlled to minimize fan noise. The Differential Fan Speed Controller monitors air temperature into the fan and the coolant temperature at the point where it is hottest (where it exits the cavity module and is returned to the heat exchanger). As the coolant temperature rises above the ambient air temperature, the controller acts to increase the fan speed. The line voltage for the fan is supplied through a solid state relay on the PCB. When the relay is on, the line voltage is connected to the fan. When the relay is off, the line voltage is disconnected from the fan. Control circuitry on the PCB switches the relay on for only a portion of each AC cycle - as coolant temperature increases above air inlet temperature the relay is left on for a longer portion of the AC cycle, increasing the electrical power to the fan (the fan spins faster).

Refer to 8-18 in Section 8. The Fan Speed Controller PCB has an on board low voltage power supply, which supplies ±15V to the board. The three inputs to the Fan Speed Controller are the Hot Water Sense, Cold Air Sense and the TACH_INPUT (from the tachometer PCB).

The Hot Water and Cold Air Sense inputs are generated by two external silicon temperature sensors. One lead from the Hot Water Sensor is tied to +15V and one lead from the Cold Air Sensor is tied to -15V. The remaining leads from the two thermistors are tied together forming a summing node (AD590_SUM_CURRENT) to the input of U2A pin 2 the Temperature Sensor Current Summing Amp circuit. As the coolant gets warmer, the input of U2 will go more positive and if the air gets cooler, then the input will go more negative. The amplitude of the output signal from U2 pin 1 is clamped by the diode D6 and is asserted to the inverting side of U2D pin 13 (the first stage of the differential amplifier circuit). At the Tachometer PCB, a signal is generated by way of an LED (U4) reflected off of a reflected tape on the cooling fan blade. The reflected LED light (TACH_INPUT) is detected, amplified and asserted to the inverting input side of the integrator U2B pin 6. (The voltage signal from the Tachometer Integrator will determine the idle or minimum speed of the fan.) The voltage output signal from U2B pin 7 is applied to the HI/LO Speed Limiter circuit (voltage divider network) and then combined with the clamped signal from U2A, which is also asserted to the inverting side of U2D pin 13. The positive output signal from U2D pin 14 is asserted to the inverting side of U2C pin 9. A negative voltage output is asserted to the inverting inputs of U1C pin 8 and U1B pin 7. A rectified mains AC signal from BR1 is asserted to the inverting inputs of U1A pin 2 and U1D pin 13. The outputs of U1A and U1D will turn Q1 on/off, resulting in a sawtooth waveform produced at the output of U1A pin 1 (TP1). The sawtooth waveform is asserted to the non-inverting side of U1C pin 10 and U1B pin 7. The output signals from U1B & C becomes the FAN_CONTROL+ input signal to the positive side of the solid state relay (triac) U2 on the AC Control PCB. U2 will in turn control the speed of the cooling fan.

4.3.1 Components

Motor and Pump Head: A 1/4 hp induction motor is used to drive the pump head. The motor is thermally protected as well as fused on the mains transformer, T1 secondary. Refer to the Interlock schematic for details. The pump head is a positive displacement, graphite vane pump. This pump uses the water as a lubricant and must never be run dry. The pump and motor are shaft coupled and mounted inside the chassis on the left rear side. A manifold is attached to the pump head which routes the water through the system as shown in the coolant flow diagram.

Particle Filter: a replaceable filter 5µm particle filter is installed in the coolant loop to trap any particles larger than 5µm in size. Particles may come from dirty water, non deionized water, dirty water containers, teflon tape and pipe dope used in the plumbing system, pump head wear and from metal corrosion within the coolant loop. Normally the water should remain clean and the filter element should be white in coloer. Brown discoloration typically indicates dirty water and metal corrosion. Black discoloration typically indicates pump head wear. All water is directed through the particle filter each pass.

DI Cartridge: A replaceable deionizing cartridge is installed in the coolant loop to remove any ion charged particles in the water. Charged particles ay cause galvonic corrosion when in contact with dissimilar metals as well as high voltage arcing in the flashlamp cavity. Charged particles usually come from using non deionized water and from absorption of metal atoms in the cooling system. Systems that do not operate often or have been filled with non deionized water will have highly conductive water, which over time, will be reduced as a portion of the water is directed through the deionizing cartridge with each pass.

Heat Exchanger: A four row copper heat exchanger (radiator) is installed at the bottom of the chassis. All of the water is passed through the radiator, directly from the flashlamp cavity. Heat from the water is absorbed by the copper and dissipated through convection to cool the water. Once out of the heat exchanger, the water returns to the main reservoir (tank). The radiator also contains a drain fitting and hose, which enables the system to be drained. Once filled, draining will still leave small amounts of water in the cooling loop. If the system is hen exposed to freezing temperatures, these pockets of water can freeze, expanding to create failures in the solid portions of the coolant loop (especially the heat exchanger).

Air Fan/Motor: An electronically speed controlled induction motor is directly shaft coupled to an impeller type rotary fan which is mounted above the heat exchanger. The rotation of the impeller is such that it draws (the coldest) air up from the floor through the exchanger out the sides and rear of the console. As the air temperature increases, the rotational speed (RPM) of the fan is increased. The pressure drop across the heat exchanger, area of the heat exchanger, volume of air flow through the heat exchanger and the ambient air temperature all have an effect on the cooling performance of the entire system.

Main Reservoir (tank): Mounted directly above the heat exchanger, the main reservoir contains the majority of the water. The water comes in from the heat exchanger and is stored here until drawn up by the pump head.

Fill Reservoir (tank): A small white fill reservoir is mounted behind the laser head under the console top cover. This fill tank should be 1/2 full after the air is removed from the cooling system. A yellow cap on the tank prevents the water from spilling out.

Cavity/Manifold: After passing through the water particle filter, the coolant make its way to the laser manifold where it enters the cavity. The cavity which mounts to the manifold contains a YAG rod and a flashlamp, both contained in a glass-like material surrounded by barium sulfate powder (highly reflective). The cooling water flows in direct contact with the YAG rod and flashlamp outer surfaces to remove the heat. Water enters on one side of the cavity and exits the other. All openings are sealed by special o-rings which are made of materials to withstand degradation by heat and UV exposure. Refer to fig. 4.2.

4.4 CONTROL ELECTRONICS

Refer to schematics 8-8 thru 8-17 in Section 8 and other associated schematics.

4.4.1 Overview

The control electronics excutes stored software instructions to safely operate the system in response to user inputs. The microprocessor system provides overall control of the system operation. It includes the following circuits / functions.

Microprocessor (µP) - Runs the main software program to provide overall control of system operation. It includes a 68000 microprocessor and its supporting circuits - ROM, RAM, programmable timer, EPLDs, clock, and microprocessor bus support circuits. Described in subtopic 4.4.2.

Shutter/Footswitch/Remote Interlock Circuit - Operates and monitors the position of the shutter; detects footswitch position; and monitors the Remote Interlock connection. Described in subtopic 4.4.3

Servo Motor Circuit - Positions the servo motor to point the servo imaging mirror to the selected Ho:Yag / Nd:YAG head. Described in subtopic 4.4.4.

HVPS & Lamp Control Circuits - Provides voltage level, lamp select, charge command, and triggering inputs to the HVPS and lamp control circuits. Monitors status line inputs from the HVPS. Described in subtopic 4.4.5.

Energy Monitor Circuits - Provides two channels of YAG pulse energy monitoring. Described in subtopic 4.4.6.

LCD Color Display and Remote Control Circuits - Provides user display and input functions. Described in subtopic 4.4.7

Aiming Diode Laser Circuit - Sets the aiming diode laser to its off, low, medium, or high intensity. Described in subtopic 4.4.8.

Fiber and Blast Shield Position Sense Circuits - Monitors the position of the fiber and blast shield. Described in subtopic 4.4.9.

Service Attenuator Circuits - Operates and monitors the position of the service attenuator. Monitors the condition of the service and diagnostic push-buttons located on the CPU PCB. Described in subtopic 4.4.10.

Low Energy Attenuator Circuit - Operates and monitors the position of the low energy attenuator. Described in subtopic 4.4.11.

4.4.2 Microprocessor

Refer to 8-8 in Section 8. The Motorola MC68000 microprocessor U64 reads/writes to its memory and I/O devices over a 23 bit address bus and 16 bit data bus. The following ICs generate clock signals to operate the various discreet devices throughout the Controller PCB:

- U59 generates a 16 MHz clock signal to the microprocessor and the ChipSelect/ Interupt EPLD U62. The 16 MHz signal can be seen at TP83.
- U48 generates a 2.457 MHz signal to the Multifunction Programmable Timer U47.
- U34 generates 1 MHz signal to the Safety Control Logic EPLD U40.
- U65 generates a 24 MHz clock signal to the Lamp Volts Frequency and the Lamp Energy Frequency Generators U45 and U46.

U62 serves as:

- A chip select function to decode the upper four bits of the address bus to enable the appropriate memory or memory mapped devices.
- A /DTACK/ generator which communicates to the microprocessor that data has either been sent or received by the EPROMs, RAM, NVRAM, EPLDs, A/D converter or D/A converter and all other peripherals.
- A clock decoder which generate 1, 2, 4 and 8 MHz clock signals to operate the Digital Input/Output EPLD U49, Multifunction Programmable Timer U47, Safety Control EPLD U40, A/D converters U30 and U31.

At power up, U56 outputs /RESET/ and /HALT/ signals to the microprocessor - the microprocessor does not execute the software instructions when both lines are low. Pressing the Reset Switch SW5 provides the same reset when the system is already on. After approximately 200ms, these lines goes high, the microprocessor begins to execute the software instructions stored in the EPROM U63.

U56 will also drive the /RESET/ line low if the 5 VDC supply voltage falls below ≈4.65 VDC. The /RESET/ signal is used to reset the following chips:

Multifunction Programmable Timer U47
All EPLDs U39, U40, U49 and U62
System Dual UART U42
Lamp Volts Frequency Generator U45
Lamp Energy Frequency Generator U46
Test DAC U32
Servo controller U50

U52 and U53 provide 2K of 16 bit nonvolatile read/write memory to the microprocessor. System energy calibration and error factors stored in the NVRAM will be maintained even when power is removed.

U63 is a four megabit PROM (programmable, read-only memory). Software instructions are permanently stored on this chip. Software upgrades can be accomplished by replacing the PROM.

NOTE: Consult Section 6 (Parts List) for a list of P/N's for the software versions currnet at the release of this manual.

U57 and U58 provide 32K of 16 byte of RAM. The microprocessor uses the RAM to keep track of miscellaneous values while the system is turned on. Data stored in RAM is lost when the system is turned off.

Inputs from the vendor supplied DC power supply provide the Controller PCB with +5 VDC, ± 15 VDC, and +24 VDC through J1, as shown in the upper left corner of 8-5.

LED31 serves as an address strobe indicator for the microprocessor. LED31 is a dual package which displays an orange color under normal operation of the microprocessor. As U62 asserts an address strobe signal (/AS/) to the microprocessor, it will also output /BAS/ and BAS signals to LED31. As both signals turn on and off, LED31 oscillates producing an orange color. If the microprocessor or any of its associated circuits malfunction, LED31 stops oscillating adn either a red or green color is exhibited.

The Programmable timer U47 (Refer to 8-5) provides timing functions for the main processor, including the following:

1MSTIMER - At 1 millisecond intervals an interrupt request is asserted by the timer. The main processor uses this interrupt to increment/decrement various registers used to time events.

SPKR - A speaker signal is asserted by the timer to the audio amp driver circuit each time the laser is fired or a user input is detected.

SAFE_ERR_IRQ - A safety error IRQ interrupt signal from the Safety Control Logic EPLD U40.

U55 displays the various error codes and condition the microprocessor is in. The four conditions are:

Service Mode
RAM check
Standby
Ready

SW2 sets the system into service mode. Sliding SW2 inputs a /SERVICE/ signal to the Digital Input/Output EPLD U49 causing the microprocessor to go into service mode.

SW3 sets the system into autocalibration mode. Sliding SW3 to the left inputs an AUTO_CAL signal to the Digital Input/Output EPLD U49.

SW4 sets the service attenuator switch. Sliding SW4 inputs a /SERVICE_ATTEN_SW/ signal to the Digital Input/Output EPLD U49, resulting in placing the service attenuator into the beam path.

4.4.2.1 Digital I/O Circuits

Refer to page 8-9 in Section 8. The microprocessor uses digital I/Os to read in high or low logic levels from throughout the system. In this manner, the microprocessor can check the condition of various circuits, sensors and etc.

The EPLD inputs and outputs are programmable and in the VersaPulse PowerSuite is used to serve in multiple functions in the system due to the flexibility of this chip. The Digital Input/Output EPLD U49 serves as an 8-channel digital I/O for the microprocessor. The EPLD can output high or low levels to control devices such as the high voltage power supply, integrated circuits and etc.

The EPLD used for digital I/O consists of two logically independent sections; the ports and timer. The port section consists of 8 channels with 10 ports each which are bi-directional. It can output signals as well as receive input signals. There are two inputs on the EPLD to receive clock input signals (GCLK1, GCLK2).

4.4.2.2 D/A & A/D Conversion Circuits

Refer to page 8-12 in Section 8. U30 and U31 are six channel multiplexer / A-to-D converters. Each multiplexer reads their prospective analog DC voltages and convert it to digital signals. This allows the microprocessor to read the digital values which represents an analog voltage after it has received the READ / WRITE signal.

- U30 reads the following analog voltages: ±15VDC signals from U25 pins 1 and 7, +5VDC from U25 pin 8, TESTDAC signal from U24 pin 7 and WATERTEMP signal from U29 pin 7.

- U31 reads the following analog voltages: SAFETY_ENERGY signal from U21 pin 3, WATER-RESIST signal from U27 pin 6, MAIN_ENERGY signal from U20 pin 3, TESTDAC signal from U24 pin 7 and V-F_FEEDBACK signal from U28 pin 7.

U32 is a D / A converter which outputs a signal to test and checks the A / D converters. It is also used to set the comparator trip levels for the Lamp Volts & Lamp Energy Frequency Generators.

4.4.2.3 DC Power Supply Monitor Circuits

Refer to page 8-12 in Section 8. The low voltage power supply outputs are continually monitored during operation of the laser to verify that the outputs are within tolerance. Any out-of-tolerance condition results in a fault code display and laser set in STANDBY.

The microprocessor monitors the actual voltages to the +5, ±15 VDC supply outputs by reading the 12 bit digital output of the A / D converter U30. Inputs to the A / D converter U30 channels 0, 1 and 2 correspond to ±15 and +5 VDC respectively. Any low voltage output that falls below or goes above a specified voltage sets the microprocessor to display a fault code on the LCD display.

4.4.2.4 Audio Amplifier Circuit

Refer to 8-9 in Section 8. The Audio Amplifier circuit provides an audio indicator for the system status. An audio tone from a speaker sounds when the following coditions occur:

- The system has finished its self-test routine during the initial turn-on.

- A tone sounds when a system error occurs.

- A tone sounds anytime a parameter is changed.

The Multifunction Programmable Timer (U47) outputs a variable frequency SPKR signal when the various states have been satisfied to the System Audio Amp U2. The output of the circuit is connected to an external speaker which emits a tone. The speaker volume can be adjusted by adjusting R8.

4.4.3 Shutter/Footswitch/Remote Interlock Circuits

Refer to pages 8-9 thru 8-10 and 8-14 thru 8-16 in Section 8. The operation of the Shutter, Footswitch, and Remote Interlock circuits are related.

Remote Interlock refers to an external electrical jack that can be wired to a remote switch to disable the laser. If this loop is opened the laser is disabled and a REMOTE INTERLOCK message appears on the LCD color display. A dummy plug is supplied to directly connect across the loop if the customer does not wire to a remote switch. The jack is located on the system back panel.

The **Footswitch** is a dual foot operated SPDT switch with a 12 foot cable. The user depresses one of the two footswitches to fire the laser. The footswitch cable plugs into a jack on the back panel.

The **Shutter** is a solenoid operated mechanism that blocks the treatment beam path when the solenoid is de-energized, directing the beam into a water cooled beam dump. The shutter moves out of the beam path when the solenoid is energized. The microprocessor operates the shutter through one of its digital I/O ports. Safety circuits can force the shutter closed with its /NOFIRE/ signal. The beam is blocked when the shutter solenoid is de-energized. Energizing the solenoid moves the shutter out of the beam path. The position of the shutter is monitored by two slotted optical switches. The switch outputs are monitored by the microprocessor digital I/O and its associated safety circuits.

Refer to the Shutter/Footswitch/Remote Interlock Circuits Simplified Diagram (Figure 4.2) and to the associated schematics in Section 8. The footswitch is connected to the +5 VDC and ground through J16-14 on the Controller PCB. When the footswitch is not depressed, the ground is applied to the N.C. (normally closed) return (J16-11) and the N.O. (normally open) line is open. Note that the N.C. and N.O. lines are both sensed by the Footswitch EPLD. The microprocessor will monitor the footswitch status by way of the Footswitch EPLD.

Once the footswitch is depressed, the Footswitch Receiver inputs are grounded completing a current path causing the FSNC1RAW or FSNC2RAW to go low. Either of these signals are asserted to the inverter U35 pin or U35 pin 9 resulting in FSNC1 or FSNC2 signal (depending upon which footswitch is depressed) to go high. It is then asserted to pin 14 or 27 of the Footswitch Logic EPLD U39. Providing all the signals at the EPLD is at its proper state, the EPLD will output a /FSDOWN1/ or /FSDOWN2/ to the Safety Control EPLD U40. U39 will also output a /FSDOWN1B/ or /FSDOWN2B/ to illumine one of the two footswitch indicators LED19 or LED0 (both green). If an error occurs, U39 will output a /FSERROR1/ or /FSERROR2/ signal illiminating LED19 or LED20 (both red). If the Safety Control EPLD U40 is at its proper state once the footswitch is depressed, U40 will output a low /SHUT_H_DRV/ and /GATED_SHUT_DRV/ signal to the Safety Shutter Drive circuitry to move the shutter out of the beam path. If the footswitch is not depressed, the FSNO1RAW/FSNO2RAW signal would go low causing U35 pin 4 or pin 8 to output a FSNO1/FSNO2 signal to go high. The high signal is asserted to the EPLD U39 pin 16 or pin 28 resulting in the EPLD to hold the signal outputs at pins 102 and 105 high preventing U40 from moving the shutter out of the beam path.

The interlock loop is part of the digital I/O loop and is sensed by the microprocessor. If the CDRH Interlock was to become disconnected the ground path for the /CDRHRAW/ signal opens and the signal goes high. This signal is asserted to the input of U41 pin 13 causing the CDRHBUF signal to go low. The low CDRHBUF signal is asserted to the input (pin 17) of the Digital Input/Output EPLD U49 which the microprocessor reads, then displays a fault on the LCD display.

Assuming that the interlock loop is complete and the footswitch is depressed, the shutter will be opened when the Footswitch Logic EPLD U39 outputs a /FSDOWN1/ or /FSDOWN2/ signal to the Safety Control EPLD U40. U40 will then output a /SHUT_H_DRV/ and /GATED_SHUT_DRV/ signal to turn on Q2 and Q4 (a dual MOSFET package).

The first stage of the dual MOSFET package Q4 operates momentarily (≈150ms) each time Q2 turns on to bypass the shutter solenoid current around resistor R71 as the shutter is moved into place, then turns off to drop the shutter solenoid current to a lower "holding" level.

Shutter position is monitored by U5 and U6 on the Optics Bench PCB. The two are complementary for the two shutter positions (opened or closed) one switch is blocked and the other is unblocked. Both devices are supplied with +5 VDC and return ground from the Optics Bench PCB.

NOTE: Each of these circuits are all interlocked together.

4.4.4 Servo Motor Control Circuit

Refer to pages 8-9 thru 8-10 and 8-21 in Section 8. A rotating mirror is used to multiplex (up to) four Ho:YAG head outputs into a single beam path. A servo motor is used to precisely position this imaging mirror to any one of the four possible YAG head outputs. The mirror is mounted to the end of the motor shaft, at a slight angle, so that as the shaft rotates through 360•, the mirror orientation changes. Between YAG pulses the mirror must be moved to and stopped at the point in its rotation that aligns it with the output coupler of the head that will be fired next. After the pulse, it must be moved to the next head to be fired, and so on for as long as firing continues. 90• x 4 = 360•.

Refer to the Servo Motor Control Circuit Simplified Diagram (Refer to Fig. 4.3) and to the associated schematics in Section 8. Motor controller U50 receives position commands from the microprocessor over the Address and Data bus. It outputs direction and pulse commands (which are buffered by U54) to the Servo Motor Control PCB digital signal buffer U1. U1 outputs a buffered signal to the H Bridge Motor Driver U2 which provides switched DC to the motor, in the polarity indicated by the direction input from the motor controller, and in time increments as indicated by the pulse input. Note that in the VersaPulse Select III the motor always moves in the same direction, but the reverse direction signal is still used to providing braking force as the motor approaches a new stop position.

Motor movement and position information is fed back to the motor controller from an optical encoder located behind the motor. The channel A and B feedback lines each provide 2000 counts per revolution, and are offset 90• from each other to provide a total of 4000 counts for one rotation. The position sensor also detects a specific position, referred to as the index position. The index position information is reported to the microprocessor through a digital I/O input port as SERVO_INDEX_BIT. Once the index position is found, the

motor controller tracks position by monitoring the channel A and B lines from the position sensor to determine the sum of the movement away from this known index position. SERVO_INDEX_BIT = high when pointed at plano #1.

4.4.5 HVPS & Control Circuits

The HVPS and Control Circuits oversee the control and turn-on of the flashlamps, monitor the voltage on the capacitor bank, and monitor several status signals from the high voltage power supply.

Refer to the HVPS & Interface Circuits Simplified Diagram (Figure 4.4) and to the related schematics in Section 8. The capacitor bank is charged by a Coherent manufactured high voltage power supply (HVPS). The control circuit on the Controller PCB sends the HVPS a LAMP DR. I, II, III or IV signal, LAMP_MOD, LAMP_VOLTS signal and the CROWBAR signal. The HVPS sends a CROWBAR_OK and F-FEEDBACK signals to the Controller PCB.

To turn on a particular flash lamp, the Safety Control Logic EPLD U40 on the Controller PCB routes a fire pulse (L1_LAMP_DRIVE, L2_LAMP_DRIVE, L3_LAMP_DRIVE, or L4_LAMP_DRIVE) through the Fiber Optic Driver (U19) and then to one of the four transmitters on the Controller PCB. When the fire pulse is asserted, the selected transmitter will turn on, emitting a 660nm light through the fiber optic to the HVPS. Enabling the Insulated Gated Bipolar Transistor (IGBT) driver PCB and turning on the IGBT. Creating a complete path for current discharge through the selected lamp.

CHARGING PROCESS - The microprocessor first calculates the lamp energy parameters required to provide the selected pulse energy at the selected pulse rate. The selected energy and pulse rate index a lamp energy current value in the stored calibration data. The data is established during automatic laser calibration and updated by light feedback information from any previous pulses at the selected operating point.

The first pulse of a treatment delivery (i.e., the first pulse after the footswitch is depressed) includes a correction factor to compensate for differences in cavity output that occur before the thermal lens has formed. Subsequent pulses do not require this correction factor.

The microprocessor writes the digital value for the required voltage to the Lamp Volts Frequency Generator U45. U45 outputs a frequency range of 0 to 100kHz for a main capacitor charging voltage of 400 volts to 800 volts. The voltage / frequency signal is sent an amplifier U43 and out through transmitter XMIT6 to become LVOLTS, of the Controller PCB to the HVPS module. In the VersaPulse Select III, the lamp voltage is fixed at 800 VDC.

The LVOLTS drive signal from the Controller PCB enters into the Mother board on the HVPS. The signal exits from the Mother board and into the Power Supply Controller PCB as VOLTCONTROL. The signal is fed into a Frequency-to-Voltage Receiver / Converter U38 for the requested B+ voltage. This circuit converts a frequency range of 0 to 100kHz to a resistor ladder. The frequency is converted to a voltage by U38 on the Power Supply Controller at a constant rate of 10kHz per volt. An output voltage from U38-1 is filtered by two RC filters and buffered by U39-7. The output from U39-7 becomes the input to the free running A / D converter U28. The digital output becomes input to the digital latch U27, which sets the various analog switches corresponding to the requested voltage, telling the boost regulator what voltage level to change the capacitor bank up to.

The HVPS provides a V-FFEEDBACK signal to the Controller through RECV9, and U23. The signal is 4 to 8 VDC for a capacitor charge level of 400 to 800 Volts. The microprocessor ADC circuits read this voltage.

TURNING ON A LAMP - Turning on a lamp consists of selecting the appropriate lamp for discharge, then providing a trigger to cause the discharge at the appropriate time to provide the selected pulse interval.

Each flash lamp has an IGBT in series with it. The four sets of flash lamps and IGBT's are connected in parallel (as shown in the block diagram). Each IGBT gate is connected to a IGBT driver circuit (located on the IGBT Driver PCB). When triggered, the IGBT driver circuit gates its associated IGBT on, establishing a current path for discharge of the capacitor bank through the associated lamp. The lamp current or lamp energy is controlled via the LAMPMODULATE signal, which establishes the "on" time of the IGBT.

Prior to firing, the following series of steps occur:

- The microprocessor, by way of U40, determines which head is to be fired and asserts the appropriate digital output signal (L1_LAMP_DRIVE, L2_LAMP_DRIVE, L3_LAMP_DRIVE and L4_LAMP_DRIVE). These four lines are asserted into the inputs of the Fiber Optic Driver U19. The U19 outputs are attached to a red transmitter (XMIT1 through 4). Optical fibers carry the signal from the XMIT's to receivers (RECV 1 through 4) on the Mother Board.

- The microprocessor then by way of U40, outputs the appropriate LAMP CURRENT SELECT signal from the analog multiplexer U2 on the Power Supply Controller PCB. The signal is then sent to the appropriate IGBT driver circuit, resulting in the output of an IGB-TON signal to the IGBT Driver PCB. This enables the IGBT Driver PCB turning on the base of the IGBT.

4.4.6 Energy Monitor Circuits

Refer to the Energy Monitor Circuits Simplified Diagram (Figure 4.5) and to the associated schematics in Section 8. The VersaPulse PowerSuite measures the energy of each YAG pulse. Two separate channels measure the energy. These two channels are required to provide safety redundancy.

- MAIN_ENERGY - Laser energy feedback loop signal (light regulation).

- SAFETY_ENERGY - Provides a second laser energy feedback loop for safety (redundancy).

The measurement is accomplished by directing a percentage of the pulse to strike a pyrodetector. The detector outputs a current, which is proportional to the energy in the pulse. The current signal is converted to a voltage, integrated and then the result of the integration is held for reading by the microprocessor ADC circuits (the microprocessor reads the energy monitor circuit output after each pulse). After the energy monitor outputs are read, the circuits are reset until the next pulse. Each circuit is calibrated by adjusting a potentiometer.

The remainder of this subtopic describes the MAIN_ENERGY circuitry and optics. The SAFETY_ENERGY circuit operates in the same manner.

A sample ('0.2%) of each YAG pulse is deflected from the first surface of the first (synthetic) sapphire wedge optic to an imaging mirror. The imaging mirror forms an image of the rod end on the PYRO1 pyrodetector (located on the Optics Bench PCB). The heat generated by this energy striking the pyrodetector generates a small current, the integral of which is proportional to the energy in the pulse. This current is amplified by U1 on the Optics Bench PCB and is asserted to the input of the Main Differential Receiver U13-3, which receives the differential voltage. The signal is sent through the Main Zero Correction circuit U16-2 (this circuit ensures that the energy monitoring circuit is at a zero level before each pulse). Depending upon the wavelength selected, the microprocessor will output a signal (MAIN_HOLMIUM or MAIN_NDYAG) by way of the Digital I/O EPLD U49 to U17 to select the proper gain stage. The energy signal is then asserted to the integrator U14. U40 outputs a /Q1/ signal to set the integrator and then as the signal is asserted to the Peak/Hold detector U20. U20 charges to the highest level seen out of the integrator for a given pulse. The /Q1/ signal also sets the Peak/Hold detector.

U20 outputs a voltage signal (MAIN_ENERGY) to the following areas:

- Analog to Digital converter U31.

  The MAIN_ENERGY signal is asserted to the input of the A/D converter U31-19 to be read by the microprocessor.

- Voltmeter output U26.

  The MAIN_ENERGY signal is asserted to the non-inverting side of the amplifier U22-3. The output becomes the input to U26 which can be read by an external voltmeter.

  NOTE: 1 Volt = 1 Joule in Holmium or Nd:YAG

Note that the energy monitoring circuit for the safety detection channel operates exactly the same as the main energy detection circuit.

The imaging mirror is used to provide a constant image size on the pyrodetector surface for different beam sizes (the beam cross section tends to be smaller as pump energy increases). This provides a more consistent energy sampling across the range of pulse energy.

After the value of the MAIN-ENERGY and SAFETY_ENERGY is read, the MAIN_ENERGY and SAFETY_ENERGY channels must be reset before the next pulse is delivered. To reset the circuit, the Safety Control Logic EPLD U40 asserts a /Q1/ signal to the following chips:

- U17 in the main energy detection channel.

The contacts 3 to 2 and 14 to 15 of U17 closes. Closing these contacts resets the main zero correction and the integrator. Closing the contacts 14 to 15 discharges C25 and C149 to reset the integrator circuit.

- U9 in the safety energy detection channel.

The contacts 3 to 2 and 14 to 15 of U9 closes. Closing these contacts resets the safety zero correction and the integrator. Closing the contacts 14 to 15 discharges C12 and C150 to reset the integrator circuit.

U40 also outputs a /4MS/ signal to reset the main and safety peak/hold detectors.

R3 and R4 on the Optics Bench PCB and R15, R61, R32, R34 on the Controller PCB sets the gain of the energy monitor circuits. These pots are to be adjusted during the energy monitor calibration procedure.

4.4.7 User Interface and Remote Control Circuits

Refer to page 8-9 in Section 8. The LCD touch screen display receives operator inputs from the user and displays the system status/operating parameters to the user.

The LCD touch screen display is a combination of an Liquid Crystal Display placed behind a digital touch screen assembly.

The microprocessor writes screen information to the System Dual UART U42 controller. The UART transmits the data (MAIN_DISPLAY_TX) in serial form on the TXDA line to the differential driver U38. U38 translates the single line input into a differential signal out on pins 5 and 6 to the LCD color display. The LCD screen provides parameters, status indications and marks off areas of the screen for user inputs.

4.4.8 Aiming Diode Laser Circuit

Refer to page 8-9 and 8-16 in Section 8 and the Aiming Diode Laser Simplified Diagram (Fig. 4.6). The aiming diode laser module is mounted on the optics plate, just prior to the fiber focus assembly, and after the safety shutter (the safety shutter can not block the diode aiming beam). The diode output is directed by a folding mirror to a beam combiner. Both the folding mirror and diode mount are adjustable, providing a far and near adjustment respectively to place the aiming beam coaxial to the treatment beam.

The aiming laser is supplied with a regulated 5 VDC through J13-1 on the Controller PCB. The regulated +5 VDC supply is switched through Controller PCB P-Channel MOSFET Q9. Q9 is turned on or off by the /LASER_DIODE_ON/ signal from the digital I/O EPLD U49 to turn the aiming beam on or off.

Aiming beam intensity is controlled by variable (digi-pot) resistance U3 on the Controller PCB connected to the aiming beam module through J13-3 and J13-4. The microprocessor sets the aiming beam intensity to high, low, or medium by changing the variable resistance (U3) using the /LASER_DIODE_STEP/ and /LASER_DIODE_DIR/ digital I/O EPLD output lines.

4.4.9 Fiber and Blast Shield Position Sense Circuits

Refer to page 8-9 and 8-16 in Section 8 and the Fiber and Blast Shield Position Sense Simplified Diagram (Fig. 4.7). The VersaPulse Select III will not allow treatment delivery if it senses that the blast shield is not inserted or that a fiber is not properly attached.

The blast shield position is sensed by a microswitch that closes when the blast shield is properly inserted. A +5 VDC pull up from the Controller PCB is applied through the microswitch, back to the Controller PCB and on to the microprocessor digital I/O EPLD through U49-20 on the Controller PCB (BLAST_SHIELD_IN). The BLAST_SHIELD_IN signal is high when the blast shield is properly inserted. Note that when the blast shield is properly inserted, LED11 will illuminate.

Correct fiber attachment is important to insure proper Z position of the focusing lens in relation to the end of the fiber. As the fiber is screwed onto the SMA connector, it forces a spring loaded cover plate inwards towards the fiber focus assembly. When the fiber is completely screwed down it provides an additional electrical connection:

> The cover plate activates a microswitch on J8-3, causing the switch to close. As the switch closes, a signal path is completed allowing the current to flow to ground. The signal /FIBER_IN_SW/ is asserted to the input of U41-9 resulting in a FIBER_IN signal output. As the fiber face physically contacts the SMA connector and fiber focus assembly housing, completing an electrical connection to ground for the /FIBER_CONNECTED_SW/ line on J8-1. The /FIBER_CONNECTED_SW/ line is inverted to become FIBER_CONNECTED. Both of these signals become input signals to the digital I/O EPLD U49. Note that LED12 illuminates when /FIBER_IN_SW/ signal is low, and LED13 illuminates when the /FIBER_CONNECTED_SW/ is low.

4.4.10 Service Attenuator Circuit

Refer to pages 8-9 and 8-14 in Section 8 and the Service Attenuator Simplified Diagram. The service attenuator is inserted into the beam path during servicing to prevent damage to the end of an attached fiber (including the blast shield) and also to protect the transimpedance amplifier during the fiber alignment. It is used when the alignment of the YAG beam is not known to be good into the end of the fiber. The attenuator provides greater than 99% attenuation. The servicing engineer can activate the service attenuator by sliding SW4 on the Controller PCB. The microprocessor turns the service attenautor solenoid on, placing the attenuator in the beam path. Position is sensed by a slotted optical switch, and when in the beam path, the "ATTEN IN BEAM" message is displayed on the LCD color display. Note that LED26 illuminates when the service attenuator is closed.

Closing switch SW4 on the Controller PCB provides the ground return path for the +5 VDC pullup, generating a /SERVICE_ATTEN_SW/ input signal to the digital I/O EPLD U49-27. U49 will then output the following signals:

- A /SATEN_H_DRV/ signal
- A /GATED_SATEN_DRV/ signal

The /SATEN_H_DRV/ signal will invert to turn on Q5 completing the current path, resulting in turning on the first stage of Q3 for 100ms. This bypasses the current resistor R70 causing the solenoid to energize, moving the attenuator into the beam path. U49 will also output a /GATED_SATEN_DRV/ signal, which gets inverted turning on the second stage of Q3. After the 100ms timeout, Q5 turns off redirecting the current through R70, across the service attenuator solenoid and then through Q3. The attenuator position is monitored by a slotted optical switch U3. The /SERV_ATENIN/ line goes low when U3 is blocked and grounded when the switch is not blocked. The signal becomes the input signal to U61 which gets inverted to S_ATEN_IN and becomes the input signal to the microprocessor digital I/O EPLD on the Controller PCB.

4.4.11 Low Energy Attenuator Circuit

The Low Energy Attenuator Circuit inserts attenuation into the beam path to allow the VersaPulse PowerSuite to provide treatment pulse energies lower than the minimum pulse energy available out of the cavity.

The micoprocessor asserts a low /ATTEN_H_DRV/ and /GATED_ATEN_DRV/ signals which becomes inverted by U61. The high output signal from U61-4 is applied to the base of Q7. Q7 completes the ground return path for the +24 VDC turning on the first stage of Q6 for 100ms. As Q6 turns on, the current flow bypasses the current resistor R73 resulting in the turning on of the low energy attenautor solenoid and inserting the low power attenuator into the beam path. At the same time Q7 is turned on, the inverted /GATED_ATEN_DRV signal turns on the second stage of Q6 completing the current path for the low energy attenuator solenoid. After the expiration of the 100ms, the first stage of Q6 turns off redirecting the current flow across R73 and then through the second stage of Q6. The low energy attenuator is located on the Low Energy Attenuator PCB.

The Low Energy Attenuator /ATTENIN/ is the output signal of the slotted optical switch U1 on the Low energy Attenuator PCB.

When the switch is blocked, its sensed output is low. When the switch is not blocked its output signal is high. The switch is blocked when the attenuator is energized, blocking the beam. The sensed line from U1 is sent from the Low Energy Attenuator PCB to the Controller PCB, J27-4 to J12-4. When the solenoid is energized, the low energy attenuator is in the beam path, U1 output is low. The low output is inverted to become ATTENIN which becomes the input signal to the microprocessor by way of the Digital I/O EPLD U49-25. The ATTENIN signal also illuminates LED24.

4.5 FLASHLAMP POWER CIRCUITS

Refer to the IGBT Driver PCB schematic page 8-19 in Section 8, and the HVPS & Control Circuits Simplified Block Diagram in topic 4.4.5.

Flashlamps are used as the exciter (pump) mechanism for the lasers. The flashlamps are a gas discharge device designed to produce intense pulsed radiation (visible, IR and UV) flashes. Its construction consists of a sealed, xenon filled, linear quartz tube, with a tungsten based cathode on one end and a pure tungsten anode on the other end. Tube and electrode materials, as well as size and shape, gas composition and pressure, all contribute to the overall performance of the flashlamp which will not be discussed here.

When used in conjunction with the HVPS, the flashlamps operate in two modes: simmer and discharge. Both modes generate heat in the lamp which is carried away via closed loop, water to air heat exchange.

In simmer mode, the flashlamp is controlled by the HVPS to simmer, or to maintain a steady state partial ionization in the flashlamp between flashes. This is accomplished by the Simmer Control, as described earlier, which maintains a low current (150mA) DC arc between electrodes. It is not unusual to observe voltage fluctuations as great as 50 Volts with a fixed simmer current over a period of seconds. Arc wander in the lamp bore and rapid changes in the positions of arc atteachment on the electrode tips are the cause of this behavior. This normal behavior is seen as “winking” of the lamp ionization.

In discharge mode, and since the lamp is conducting (in simmer mode), the plasma field is almost instantaneously developed as soon as the lamp is triggered (IGBT turns on). This period of time is characterized by rapidly increasing current through the lamp, usually occupying the first 15 to 20% of the rise time of the current pulse through the lamp. This interval of rapid arc expansion during which the energy required to stabilize the plasma in the tube is being dissipated along the tube wall and electrodes. Once the arc is stabilized, the remainder of the pulse duration (80 to 85%) consists of slow and controlled arc growth, and the stabilized plasma discharge occurs at high current. During discharge, extreme temperatures are developed on both eletrodes and in the quartz tube.

Lamp lifetime is primarily by four factors:

- Degradation of the electrodes (eletrode wear) which results in deposition of chemical and metalic inside the tube and vlocks light emission from leaving the tube.
- Aging and destruction of the quartz tube typically due to improper handling (finger oil contamination) and overstressing (overheating) the lamp.
- Contamination of the gas, either by leaking seals or tube cracking or by electrode wear.
- Failure of electrode seals, again usually a result of improper handling, flexing lamp leads, etc.

The flash lamp power circuits include the HVPS, simmer / start controller, IGBT Driver PCB, capacitor bank circuit, flash lamp IGBT's and the flash lamps. These circuits operate together to start and simmer the flash lamps between firings; charge the capacitor bank before firing; and then trigger the discharge of the capacitor bank through the selected flash lamp via the IGBT.

Simmer - The flash lamps are simmered at a low current (≈150mA) between pulses simply to maintain the electrical path to the IGBT anode side - i.e., if the lamp was not conducting (open circuit on lamp cathode side) the IGBT could not be gated on. The lamp is simmering but the rod is not simmering. The simmer / start controller board provides a separate simmer supply current for each flash lamp, as well as supplying a transformer coupled RF field around each flash lamp to promote ionization of the flash lamp at turn on. The RF field is established by connecting a transformer secondary to the cavity housing, which is electrically isolated from the chassis. The Simmer / start board operates off of B+ supplied by the HVPS.

Charging the Capacitor bank - For the VersaPulse PowerSuite laser, the capacitor bank charges to 800 VDC. The circuit is monitored by the Frequency to Voltage converter (U13) and is read by the main Analog to digital converter U31 as V-F_FEEDBACK signal.

There are four identical IGBT driver circuits on the IGBT driver PCB - one for each of the four flash lamp circuits. Each has an optical fiber input from the Controller PCB, and an output to its associated flash lamp IGBT. All four circuits are functionally the same - the LAMP I circuit operation will be described in the next paragraph.

To turn on flashlamp #1, the Controller PCB sends a pulse of infrared light through the optical fiber connected to RECV 1. RECV turns on, turning on its associated AND gate U9. U9 will enable the appropriate logic circuit, close the appropriate configuration switches and turn on the IGBT connected between B- and the cathode of the flash lamp. The IGBT turns on, providing a discharge path for current from the capacitor bank through the flash lamp and IGBT to capacitor return.

4.6 OPTICS

The optics include all components that act on the aiming and / or treatment beam. This includes the YAG cavity module; YAG combining optics; folding mirrors; the energy sample optics; shutters; attenuators; aiming beam laser and combining optics; the fiber focusing lens and blast shield.

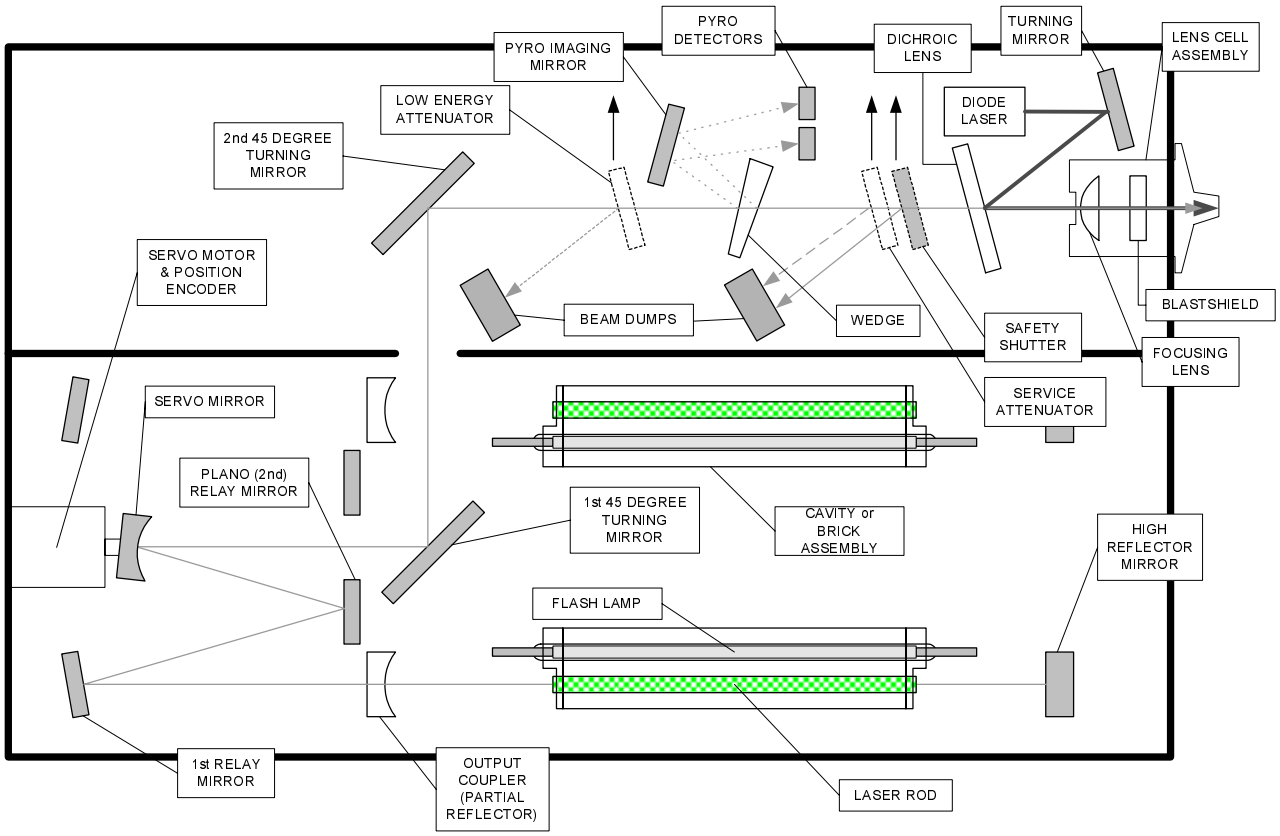


FIG. 4.2: Optical Schematic

YAG CAVITY - The YAG cavity provides pulsed output of 2.1 or 1.06 (depending upon crystal) micron wavelength light energy. The cavity is pumped with a xenon flash lamp. The lasing medium is either a Ho:YAG or Nd:YAG rod. The rod is positioned between an HR and OC mirror. Up to four such cavities can be housed in a single VersaPulse PowerSuite system.

MULTIPLEXING OPTICS - The multiplexing optics consist of an imaging and flat mirror for each cavity, and the servo positioned imaging mirror. For each cavity, an imaging mirror directs the OC output off a flat mirror to the surface of the servo positioned imaging mirror. The servo positioned mirror can be rotated to line up with each of the up to four YAG beam paths, so that each output is directed down a common beam path.

COMMON BEAM PATH - the servo positioned mirror output is directed through two folding mirrors towards the fiber focusing lens. In its path are the following additional optical components.

Low Energy Attenuator - The LE attenuator can be inserted into the beam path to decrease the treatment beam power. This allows the system to deliver pulse energies lower than the lowest stable pulse energy available out of the YAG head.

Wedge Optic - A wedge optic is required to check the power after the low energy attenuator. Two samples are reflected off the wedge, both are used. An imaging mirror directs the sample towards a pyrodetector mounted on the Optics Bench PCB. The pyro circuitry translates the energy sample into a voltage proportional to the energy of the YAG pulse. The signals reporting back to the CPU PCB is MPREA and SPREA.

Service Attenuator - The service attenuator is inserted into the beam path to attenuate the treatment beam before it is focused into the end of the fiber. It is operated by switch sw4 on the Controller PCB inside the unit accessible to the servicing technician. The attenuation is used during alignment procedures.

Safety Shutter - Blocks the treatment beam path when de-energized.

Aiming Beam Diode and Combiner Optic - A red (650 nm) aiming beam is provided by a diode laser mounted in the optical head. The user can turn the aiming beam off or select high, low, or medium intensity. The diode output is directed by a folding mirror to a beam combiner in the primary beam path. The combiner and folding mirror are both adjustable to allow for placing the diode aiming beam coaxial with the treatment beam.

Fiber Focus Lens - Focuses the beam into the fiber and to a beam diameter of approximately 260µm.

Blast Shield - Protects the Fiber Focus Lens from debris ejected from the proximal end of the fiber during a fiber failure.

4.7 SOFTWARE

The software also provides non-treatment functions (for service personnel) after it detects an ON-to-OFF transition of the service switch on the Controller PCB. It switches the LCD display from the user screen to the service screen when it detects the transition. The LCD display goes back to the user screen when the system is turned off and turned back on.

NOTE: No all faults are reported in service mode.

The following provides a summary structure of the system software in user mode as well as in service mode.

SYSTEM INITIALIZATION AND POWER UP:

The following describes the system initialilzation tasks performed by the VersaPulse PowerSuite system software on the system power up. Upon power up, the VersaPulse PowerSuite software shall initialize and test the following:

- Power up
- Self-Test
- Calibration

Once these tasks have been completed, the software will do the following:

- Display results of the diagnostics and calibration routines.
- Sound beeper, marking the completion of the power up initialization.
- Paint the user mode screen or if the service switch is set for service mode, the service screen will be painted.

NORMAL SYSTEM OPERATION:

After the system has successfully completed the power up self-test and initialization, the system will be gin its normal operation in either User or Service mode.

During normal operation, the system software will start performing the following on-going routines:

1. Monitor user inputs as follows:

a. Input to the control panel: identify which button is pushed and act on it.

b. Input to the remote control: identify which button is pushed and act on it.

c. Restrict operation to settings within the limits specified for the model in use.

d.Footswitch: determine if treatment is requested, or cable unattached or broken.

e. BRH interlock.

2. Input and output system data as follows:

a. Display user selected operational parameters on the control panel and the remote control if one is present.

b. Display status and error messages as appropriate.

c. Output data to digital and analog I/O lines to control hardware.

3. Monitor system operational and safety functions.

a. Have sufficient redundancy to still identify hazards and shut down safely if single component fails.

b. Halt system operation or suspend operations as needed to maintain a safe state if hazard is indicated.

c. Prevent unwanted emissions.

d. Detect unwanted laser light or overpower shots.

4. Start and monitor laser treatment as required.
5. Manage audible tone generation.

(The VersaPulse Power Suite system will remain in the normal mode of operation until one of the following occurs:

- Service mode is activated
- A fault is detected
- The system is powered off

SYSTEM STATES TO BE IMPLEMENTED:

1. Startup

Startup state will be entered automatically on power up. The system will execute its self-test and calibration. If this is executed successfully, the system will enter into a Standby or Service Standby state, depending on the setting of the Service switch. If errors are detected, the system will remain in a Startup state until the Service switch is activated, whereupon it will enter a Service Standby state.

2. Standby

Standby state will be entered

- From Startup state after power up initialization is completed.
- From ready statewhen the STANDBY button is pushed.
- From READY state when the system has been idle for five minutes without a control activation.
- From error state when the error condition is cleared; for clearable errors the user must press the STANDBY or READY button.

The system will remain in STANDBY state until the Ready button is pressed and no system fault is in effect. The understanding of STANDBY is that the system is powered on, has passed calibration and is monitoring safeties, but is neither primed to fire nor physically able to emit light due to mechanical and electrical interlocks.

In Standby state the system will

- monitor power supplies, the safety shutter, the control panel, the footswitch connection, the delivery fiber connection and the BRH interlock
- prevent the system from firing
- keep the safety shutter closed

3. Ready state

Ready state will be entered only under the following conditions:

- From Standby state when the Ready key is pressed, all safety tests have been completed and no errors are present.
- From Treat state when treatment is ended eithout error.

In Ready state the system will

a. Monitor the power supplies, the safety shutter, the control panel, the footswitch connection, the delivery fiber connection and the BRH interlock.

b. prevent the system from firing.

c. Keep the safety shutter closed.

d. Monitor the footswitch.

(If the footswitch is pressed and there are no errors, the system will go to Treatment state after verifying that the enery-monitoring ADC is working correctly.)

4. Treatment State

The Treatment state will be entered from the Ready state when the footswitch is pressed and there are no errors.

In Treatment state the system will do the following:

a. Stop monitoring the control panel.

b. Verify that the limits on pulse energy and pulse rate correspond to requested values.

c. If firing the Holmium laser, preheat the laser rod.

d. Open the safety shutter.

e. Set the low-energy attenuator as required.

f. Fire the laser.

g. Monitor the laser output using both energy monitoring channels.

h. Halt firing if measured pulse energy or pulse rate are outside the specified limits.

i. Monitor the power supplies, the safety shutter, the control panel, the footswitch connection, the delivery fiber connection and the BRH interlock.

j. Monitor the footswitch.

k. If the footswitch is released, end treatment and return to Ready state.

l. When the footswitch is released or a fault is detected during treatment, the sytem will do the following:

- Stop firing the lamps (after the pulse set up or running has completed).
- Close the safety shutter.
- Enable the control panel monitoring.
- Go back to Ready or Error state if a fault is detected.

SYSTEM MONITORING:

1. Upon power up and self-test, the system will perform the following initializations:

a. Configure the digital I/O chips and set the outputs to their defaults.
b. Test various CPU features and stacks.
c. Set all analog outputs to their safe default state.
d. Test the data memory.
e. Initialize the data memory.
f. Check the nonvolatile memory. Calculate its checksum and compare with stored value. Failure causes memory to be reinitialized to default values.
g. Check the ROM. Calculate the CRC and compare with stored value. If the test fails, the system will set a permanent error and display the calculated CRC value.
h. Initialize serial communication with the display.
i. Display the Power-On Self-Test (POST) screen.
j. Display results of each self test with PASS or FAIL or fault that caused failure or abort.
k. Check the low voltage power supply voltages.
l. Check the DACs by readback on the ADC.
m. Test the safety shutter by moving it to both positions and reading its position sensors.
n. Test the low energy attenuator by moving it to both positions and reading its position sensors.
o. Test the footswitch EPLD.
p. Check and calibrate the fiber optic communication with the power supply.
q. Check the crowbar operation.
r. Verify that all flashlamps are working.
s. Calibrate all lasers.
t. Calibrate the low-energy attenuator at all wavelengths present in the model in use.
u. Test the Safety EPLD as described below.

OPERATIONAL MONITORING:

1. System Monitoring During Standby State

a. In Standby state, the system will monitor the following:

- Footswitch connection

  If no footswitch is connected, the system shall display a message and remain in Fault state.

  When a working footswitch is connected to a dual-wavelength system, the system will display whether it is a single or double-footswitch. This requirement applies only to dual-wavelength systems.

  When a working footswitch is connected and the only error in effect is that there is no footswitch, the system will go to Standby state automatically.

  If the footswitch is defective (if both contacts are in the same state for more than a few seconds) the system will display a message and go to a Fault state.

- Remote Interlock Connection

  If the remote interlock is disconnected, the system will display a message and remain in a Fault state.

  When the remote interlock is reconnected, the system will go to a Standby state automatically.

- Fiber Connection

  If the delivery fiber is disconnected, the system will display a message and remain in a Fault State.

  When the delivery fiber is reconnected, the system will go to a Standby state automatically.

- Safety Shutter Position

If the safety shutter is open, the system will display a message and remain in a Fault State.

If the safety shutter appears to be defective (if both position sensors are in the same state for more than a few seconds) the system will display a message and go to a Fault state.

- Low Voltage Power Supplies

If the outputs of the low voltage power supplies are not within the specified tolerance of nominal, the system will display a message and go to a Fault state.

- Debris Shield

If the debris shield is removed, the system will display a message and remain in a Fault state.

When the debris shield is reinstalled, the system will go to Standby state automatically.

- All Control Panel Buttons

The system will respond to control activations.

- Service Mode Enable Switch

If the Service Mode switch is toggled, the system will enter Service mode.

- Coolant Temperature and Conductivity

If the coolant temperature and conductivity are not within the specified limits, the system will display a message and go to a Fault state.

- Inadvertent Exposure

If the system detects laser light when it is not firing, it will display a message and go to a Fault state.

- Crowbar

  If the system detects that the crowbar is active, it will display a message and go to a Fault state.

b. System Monitoring During Ready State

In Ready state the system will monitor all items listed for the Standby state.

- Footswitch for Request for Treatment

  If the footswitch is pressed, the system goes into Treatment state.

c. System Monitoring During Treatment

In Treatment state, the system monitors all items listed for the Ready state.

- Safety Shutter Position

  If the safety shutter is not in the commanded position when it should be, the system will display a message and remain in the Fault state.

- Laser Output Energy and Pulse Rate

  If the laser output energy or pulse rate are not within the specified limits, the system will go into a Fault state and display any of the following codes in the table below.

Error	Error Type	Condition
Energy high	Clearable	Energy of any pulse greater than 1.5* requested energy.
Energy low	Clearable	Energy of any pulse less than 0.5* requested energy.
Pulse rate high	Clearable	Interval between two consecutive pulses, as measured by the independent clock, less than 0.8* requested pulse interval.
Pulse rate low	Clearable	Interval between two consecutive pulses, as measured by the independent clock, greater than 1.2* requested pulse interval.
+5V power supply error	Clearable	Power supply output voltage differs from nominal by greater than 10%.

Error	Error Type	Condition
+15V power supply error	Clearable	Power supply output voltage differs from the nomical greater than 20%.
-15V power supply error	Clearable	Power supply output voltage differs from nominal by greater than 20%.

2. Testing Safety Systems

During startup the system tests the safety systems as described in this section. If any of the tests fail, the system will cause a permanent error, resulting in the system displaying a message and not allowing the user to put the system into User mode.

a. Safety Shutter

The system will verify that the nofire sets the safety shutter, preventing it from opening.

b. Independent Clock

The system verifies that the independent clock agrees with the system clock within 1% over a period of at least 100mS.

c. Inadvertent Exposure

The system verifies that the Safety EPLD can detect an inadvertent exposure, and that after an inadvertent exposure, no laser will fire.

d. Exposure Disabling Signals

The system verifies that when any one of the signals in the table below is in the indicated state, no laser will fire.

Signal	State
Nofire	Asserted
Disable1	Asserted

3. Delivering Treatment

a. Check copies of settings data.

Before firing in User mode, the copies of the duplicated settings data will be compared, and if the copies are not identical, the system will display an error message and not fire.

b. Distinctive Audible and Visible Indications.

Before firing in User mode, the system will give a distinctive audible and visible indications as to which kind of laser will fire (i.e., Holmium or Neodymium).

c. Starting with Holmium Lasers.

When starting a treatment using the Holmium laser, the system will warm up the laser rods in use by firing a sequence of pulses with the shutter closed. When the sequence is completed, the system will open the shutter and proceed to fire in Treatment mode.

When the pulse rate is such that the system is required to fire fewer than the number of Holmium rods available, the system will use a different combination of rods each time it starts firing.

d. During Firing.

While the system is firing in Treatment mode, the system controls the outputs of the individual lasers using a feedback from the main energy channel, and will monitor the outputs using the safety energy channel. The system will stop firing and display a message if pulse energy as indicated by either channel exceeds the specified limits.

e. Tropic Mode.

When firing in Treatment mode using the Holmium laser, the system will reduce the laser energy setting if the system is firing at greater than 60W and the coolant temperature rises above 40• C. The energy setting will be reduced by 4% per degree C by which the coolant temperature exceeds 40• C. The values of pulse energy at which pulse energy errors are set will be adjusted to correspond to the changed pulse energy setting.

f. Limp Model.

If a given laser rod generates more than 4 low-energy errors after power is turned on, the system will consider that a rod has failed.

If a Holmium laser rod fails, the sytem will not attempt to continue to fire the failed rod, but will continue functioning as if it were a model having a number of Holmium rods actually available, and maximum pulse rate, pulse energy and output power not greater than those available originally to the model in use. The system will display a special screen advising the user to call Lumenis Field Service and informing the user of the maximum available pulse rate and average power.

If the Nd:YAG rod in a dual-wavelength system fails, the system will continue functioning as if it were a single-wavelength model having the number of Holmium rods actually available maximum pulse rate, pulse energy and output power not greater than those available orginally to the model in use. The system will advise the user as described above.

In case of failure of a single Holmium rod, the system will behave as indicated in the following table;

Failing Model	Change to Model
Dual 80 / 100	Dual 30 / 100
Dual 60 / 100	Dual 30 / 100
Dual 30 / 100	Dual 201 / 100
Dual 201 / 100	System is non-functional
Dual 20 / 60	Dual 201 / 60
Dual 201 / 60	System is non-functional
Dual 80 / 100JPN	Dual 30 / 100JPN
Dual 30 / 100JPN	Dual 20 / 100JPN
Dual 20 / 100JPN	System is non-functional

In case of failure of the Nd:YAG rod, the system will behave as indicated in the following table:

Failing Model	Change to Model
Dual 80 / 100	Single 803
Dual 60 / 100	Single 60
Dual 30 / 100	Single 30
Dual 20 / 60	Single 20

Failing Model	Change to Model
Dual 80 / 100JPN	Single 803JPN
Dual 30 / 100JPN	Single 30JPN
Dual 20 / 100JPN	Single 20JPN
Dual 201 / 100	System in non-functional
Dual 201 / 60	System is non-functional

4. Error Handling.

a. Errors vary in level of severity and the nature of the response required. The VersaPulse PowerSuite error handler will recognize three classes of errors.

- Permanent

  The error can be cleared only by power cycling the system.

- Clearable

  The error can be cleared, the error message will no longer be displayed and the system will go Standby state when the user presses the READY button or the STANDBY button, if the tiggering condition is no longer present.

- Monitored

  The error can be cleared, the error message will no longer be displayed and the system will go to Standby state when the triggering condition is no longer present.

b. Actions taken

- Permanent Errors

  The system will enter Error state and remain there. The system will exit Error state only when the power is cycled andthe triggering condition is no longer present.

- Clearable Errors

The system will enter Error state. If the user pressesthe STANDBY button or the READY button, the system will enter STANDBY state if the triggering condition is no longer present.

- Monitored Errors

The system will enter Error state. If the triggering condition disappears, the system will enter Standby state. In all cases, the system will display appropriate messages on the control panel. The remote control will display the state of the system, but willnot display error messages.

c. Specific Errors

- Errors of the type indicated will be set under the conditions as indicated in the following table:

Error	Error type	Condition
Energy High	Clearable	Energy of any pulse greater than 1.5* requested energy.
Energy Low	Clearable	Energy of any pulse less than 0.5* requested energy.
Pulse rate high	Clearable	Interval between two consecutive pulses, as measured by the independent clock, less than 0.8* requested pulse interval.
Pulse rate low	Clearable	Interval between two consecutive pulses, as measured by the independent clock, greater than 1.2* requested pulse interval.
+5V power supply error	Clearable	Power supply output voltage differs from nominal by greater than 10%.
+15V power supply error	Clearable	Power supply output voltage differs from nominal by greater than 20%.
-15V power supply error	Clearable	Power supply output voltage differs from nominal by greater than 20%.

d. Pulse Energy 20% Error Indication.

If the moving average of the pulse energy is greater than 1.2* requested energy or less than 0.8* requested energy, the system will give a distinctive audible beep. The moving average will be calculated as follows:

At the beginning of a treatment, the moving average will be set equal to the measured pulse energy. For each pulse thereafter, the moving average will be set equal to

0.8* previous moving average + 0.2* measured energy of the current pulse

5. System Messages

The system will advise the user if any of the following conditions exist

a. Calibration disabled.

If startup calibration was disabled, the system will display a message.

b. Service Attenuator in Beam Path.

If the service attenuator is in the beam path, the system will display a message.

c. Safety Shutter Locked Open.

If the safety shutter is locked open, the system will display a message.

d. Holmium Lamp Approaching End of Life.

If any Holmium laser rods require more than 95 Joules pump energy to deliver 2 Joules laser energy, the system will display a message.

6. User Statistics.

The software will store in NVRAM a log of the laser use. The log will be accessible through a service mode screen. The following items will be stored in:

- Number of each shots on each laser.
- Accumulated time with power on.
- Accumulated time lasing.

SERVICE MODE

Service mode is a privileged mode of operation for use by manufacturing and service personnel. Service mode shall be entered by toggling the service mode switch on the Controller PCB. Access to the switch will require the use of a tool to open the laser console. Service mode will provide the following functions:

1. Service Firing.

In service firing, the user will be able to fire any laser or combination of lasers at a chosen pulse rate and pump energy; except that in a dual-wavelength system it shall not be possible to fire Holmium and Nd:YAG lasers at the same time.

In service firing, the system will not control laser output energy, nor shall it assert errors associated with pulse energy or pulse rate.

2. System Calibration

In system calibration, the system will fire each laser rod at two specified pump energies, shall measure the laser pulse energy at each pump energy and calculate the relation between pulse energy and pump energy for each rod.

The pump energy vs. pump energy relation will be calculated to give the slope and intercept coefficients in the formula

Pump energy = slope* pulse energy + intercept

If these coefficients are within limits which will not be specified in this document, but shall be determined by the Laser Engineer as he/she deems appropriate, the coefficients will be stored in NVRAM and used to set the pump energy when performing a treatment. The software engineer will be responsible for certifying that the system obeys the limits as specified.

When calibration is completed, the system will measure the optical transmission of the low-energy attenuator at each wavelength in use.

After completing the above, if the system is in Service mode, it will perform all necessary functions, including safety tests, that are required to operate normally in User mode.

3. NVRAM Initialization.

This function will initialize appropriately all values in non-volatile RAM.

4. Language Selection

This function will select the language to be used on the user-mode display. The setting will be stored in NVRAM.

5. Control of Low-Energy Attenuator Position

This function will allow the user to move the low-energy attenuator into or out of the beam path.

6. Control of Safety-Shutter Function.

This function will allow the user to require the safety shutter to operate normally, or to lock it open or closed.

7. Creation of reports.

This function will allow the user to generate specified reports about the system and transmit then from the auxiliary serial port.

8. Display Calibration Graphs.

This function will allow the user to display the graphs of pump energy vs. pulse energy for each laser individually, or for all lasers. The graphs for the individual lasers shall also show the limits allowed for the calibration coefficients.

9. Display Pulse Energy Graphs.

This function will allow the user to display a graph of pulse energy for the most recent pulses from all lasers. The user will be able to select whether the main energy readings or the safety energy readings are displayed.

10. Fire for Fiber Position Check.

This function will allow the user to fire a number of pulses from each laser. The user will be able to specify the number of pulses to be fired from each laser, which lasers are to fire, the pulse rate and the pump energy to be used. It will not be possible to fire the Holmium and Nd:YAG laser at the same time. When firing the Holmium lasers, the system will preheat the laser rods as for treatment firing, then opens the shutter, fire the specified number of pulses and close the shutter.

When firing the Nd:YAG lasers, the system will open the shutter, firing the specified number of pulses and close the shutter.

11. Display System Information.

The following system information will be displayed, in addition to the other displays specified for service mode:

- The measured output of the +5, ±15V power supplies.
- The coolant temperature and conductivity.
- The identification of the model in use.
- The ROM CRC value.
- The measured transmission of the low-energy attenuator at each wavelength present in the system.

SERVICE MODE SCREENS

The following screens will implemented in service mode. Refer to Section 5 of this service manual for illustrations of the different service screens:

1. Service 1.

This service screen contains the following controls and displays:

Pulse Rate
Flashlamp Voltage
PumpEnergy
Lamp Current
Ready / Standby
Laser Rod Enable / Disable
Laser Pulse Energy
Calibration Button
Burn-in Button
Initialize NVRAM Button
Next Screen Button

2. Service 2.

This screen contains the following controls and displays:

Language
Attenuator Position
Shutter Mode
Reports
Energy Plot
Calibration Plot
Centration
Next Screen
Low-Voltage Power Supply Outputs
Coolant temperature and Conductivity
Measured Flashlamp Voltage
Model Identification
ROM CRC
Software Version
Time On
Accumulated Lasing Time
Calibration Slope and Intercept
Accumulated Flashlamp Pulses
Low-Energy Attenuator Transmission

3. Energy Plots

This screen contains the following controls and displays:

Pulse Energy Plot
Plot Main Energy
Plot Safety Energy
Return to Screen 2 screen

4. Calibration Plots.

This screen contains the following controls and displays:

Calibration Value Table
Calibration Curve Plot
Plot All button
Plot Rod 1 Button
Plot Rod 2 Button
Plot Rod 3 Button
Return to Service 2 screen

5. Fiber Centration.

This screen contains the following controls and displays:

Centration Shot Limit
Laser Rod Enable / Disable
Ready / Standby
Fire Centration
Pulse Rate Display
Pump Energy Display
Return to Service 2 screen

SERVICE MODE CONTROLS AND DISPLAYS

In service firing, the following controls and displays are to be implemented.

1. Pulse Rate.

This consists of an auto-repeating UP / DOWN button set and a text display of the pulse rate per rod in Hertz to the nearest 0.1 Hz.

a. Pulse Rate Max

This control sets the pulse rate to the maximum available setting for the model and laser type in use.

b. Pulse Rate Up.

This control sets the pulse rate to the next higher setting.

c. Pulse Rate Down.

This control sets the pulse rate to the next lower setting.

d. Pulse Rate Min.

This control sets the pulse rate to the next higher setting.

2. Flashlamp Voltage.

This consists of an auto-repeating UP / DOWN button set and a text display of the flashlamp voltage. setting in integer volts.

a. Jump Up

This control increases flashlamp voltage by 25V.

b. Volts Up

This control increases the flashlamp voltage by 5V.

c. Volts Down

This control decreases the flashlamp voltage by 5V.

d. Jump Down

This control decreases the flashlamp voltage by 25V.

3. Holmium Pump Energy.

This consists of an auto-repeating UP / DOWN button set and a text display of the pump energy setting in integer Joules.

a. Jump Up

This control increases the pump energy by 5 Joules.

b. Volts Up

This control increases the pump energy by 1 Joule.

c. Jump Down

This control decreases pump energy by 5 Joules.

4. Nd:YAG Lamp Current.

This consists of an auto-repeating UP / DOWN button set and a text display of the lamp current setting in integer amperes.

a. Jump up

This control increases the lamp current by 5 amps.

b. Lamp Current Up.

This control increases the lamp current by 1 amp.

c. Lamp Current Down.

This control decreases the lamp current by 1 amp.

d. Jump Down

This control decreases the lamp current by 5 amps.

5. READY / STANDBY

This consists of a READY button, a STANDBY button and a display of the system READY / STANDBY status.

6. Laser Rod Enable / Disable.

This consists of a button for each laser rod. Pressing the button toggles the associated laser rod between enable (displayed as “On) and disable (displayed as “Off”). Each button contains a display of the enabled / disabled state of the associated laser.

7. Laser Pulse Energy.

This consist of displays of the energy of the most recent pulse (Joules) with resolution of 0.01 J for Holmium rods, or of the power of the most recent pulse (Watts) with resolution of 0.01 W for Nd:YAG rods. The power being calculated as the product of the energy of the most recent pulse and the pulse rate.

For each rod there is a display based on energy read by the main channel and a display based on energy read by the safety channel.

8. Calibration Button

This button starts the calibration procedure if the system is in Ready mode.

9. Burn-in Button

This button activates the burn-in process.

10. Initialize NVRAM Button

The consists of a delayed-action button. As the button is held down, the system gives a distinctive audible beep at one-second intervals. At the end of five seconds, the button function will be executed and the system gives the appropriate beep. If the key is held down after the function is executed, there will be no effect. The effect of the button is to initialize data in NVRAM to default values, or to zero.

11. Next Service Screen Button

This button switches between Service 1 and Service 2 screens.

12. Attenuator Position

This consist of a button and display of the low-energy atteunator position. The button will toggle the low-energy attenuator between the open and closed positions.

13. Shutter Mode.

This consists of a button and a display of the shutter mode. The button cycles the shutter operating mode between normal, locked open and locked closed.

14. Reports

When this button is depressed, reports of the system status and history will be transmitted from the auxiliary serial port.

15. Plot Energy

When this button is pressed, the Energy Plots screen is displayed.

16. Plot Calibration

Depressing this button displays the Calibration Plots screen.

17. Fiber Centration.

Depressing this button displays the Fiber Centration screen.

18. Draw Main energy plot

Depressing this button displays the Pulse Energy Plot based on the main energy channel.

19. Draw Safety Energy Plot.

Depressing this button displays the Pulse Energy Plot based on the safety energy channel.

20. Return to Service 2 Screen

This button returns the system to Service Screen 2.

21. Plot Calibration Data

The buttons consist of PLOT ALL, PLOT 1, PLOT 2, PLOT 3 and PLOT 4.

Depressing the PLOT ALL button will display graphs of the calibration curves of all laser rods in use. Depressing each of the other buttons will result in displaying a graph of the calibration curve of the associated laser rod.

22. Calibration Formula Display

This display will show for each rod, the coefficients of the calibration curve, to 2 decimal places.

23. Calibration Value Table

This displays a table of pump energy or lamp current for the following laser outputs:

Holmium rods - 0.5, 2.0 and 3.5 joules
Nd:YAG - 100W and 25W

24. Centration Shot Limit

This consist of an auto-repeating UP/SOWN button set and text display of the number of shots to be fired.

a. Max Shots

This control sets the number of shots to 10.

b. Shots Up

This control increases the number of shots by 1.

c. Shots Down

This control decreases the number of shots by 1.

d. One Shot

This control sets the number of shots to 1.

25. Fire Centration

This button starts the fiber-centration firing sequence.

26. Laser Rod Type Display

This display shows the type of the associated laser rod as:

Holmium
Nd:YAG
None

5.0 TROUBLESHOOTING

5.1 OVERVIEW

5.1.1 Service Philosophy

The VersaPulse® PowerSuite™ laser is designed to require little adjustment or calibration, and to detect and report hardware malfunctions by fault code or error message, displayed on the LCD color display. In most cases field failures are repaired by changing out a Field Replaceable Unit (FRU). FRU's are built specifically to support field repair, and consist of a part or group of parts determined to be suitable for field replacement. When a part fails that is a part of a FRU, normally the FRU is replaced, not the individual part.

Corrective and preventive maintenance must only be accomplished by a Service Engineer who has completed Lumenis certification service training on the VersaPulse PowerSuite laser.

Field calibration and adjustment is covered in detail in Section 3. Special purpose tools are required to maintain the VersaPulse PowerSuite laser. These tools are listed in Section 6.

The entire optical path is enclosed inside the laser head. Removing the dust cover exposes the interior to foreign matter (i.e. dust, contaminants and etc.). Minimize this exposure by removing the cover only when necessary, using a clear plastic cover over the head while the dust cover is off, and getting the dust cover back on as soon as maintenance inside the head is complete.

After power up, and before the VersaPulse PowerSuite laser moves to its standby condition, the software performs a series of self tests. Self test failures result in fault codes or error messages displayed on the LCD color touchscreen display. These fault codes provide an indication of what malfunction was detected, which should point to a specific area of the system for further investigation. Explanations of the fault codes are included in this section. Most hardware malfunctions will be detected at this time.

During normal operation the software continues to monitor for system malfunctions, and to report any detected malfunctions by fault code or error message at the LCD color touchscreen display.

Some fault codes are "logged" in a special service screen.

The VersaPulse PowerSuite laser has a series of service software routines available to the service engineer. The routines are contained in the software EPROM, and are activated by moving a switch on the Controller PCB (not accessible to the user). These routines facilitate calibration and troubleshooting. The routines are described in detail later in this section.

A service attenuator is mounted in the optics bench assembly and is placed in the beam path by enabling SW4 on the Controller PCB. The service attenuator can be used during servicing to decrease the power of the treatment beam before it enters the fiber focus assembly. This can prevent damage to an attached fiber and / or the blast shield when the laser is fired before the fiber focus alignment has been confirmed.

The microprocessor circuit includes a four digit, 5 x 7 matrix LED display mounted on the Controller PCB. The software can use this display to indicate status or type of fault information to the service engineer.

5.1.2 Safety Precautions

Lethal voltages and YAG laser emissions are the primary dangers to the Servicing Engineer. In addition to the general safety precautions which always apply when working on electronics and lasers, the Servicing Engineer must be aware of the following specific precautions:

Only Lumenis certified VersaPulse PowerSuite laser Service Engineers should attempt any service on this system.

Even with the keyswitch in the "OFF" position there are potentially lethal voltages present inside the console.

Storage capacitors inside the system are capable of holding a lethal charge, even after power has been removed from the unit.

Do not touch the YAG Cavity Module - IT IS A SHOCK HAZARD. The YAG Cavity Module is electrically isolated from the chassis ground and connected to the secondary of a transformer to develop an electrical field around the flashlamps. The YAG Cavity Module is located in the laser head.

The YAG laser light is invisible to the human eye. Because the YAG energy can not be seen, there is no visible indication of the primary or reflected beam. Eye protection that attenuates the YAG wavelength to a safe level must be worn by all persons in the area of the laser system whenever the laser is being serviced.

The YAG laser light and its reflections are potential burn hazards and can ignite flammable materials. Use extreme caution when operating the system with covers opened or removed. The covers contain the beam and reflections safely within the console. Only those persons required should be present during servicing, and eye protection that safely attenuates the YAG wavelength must be worn by all present.

The YAG laser light and its reflections are potential hazards to the eye. Use extreme caution when operating the system with the covers opened or removed. The covers contain the beam and reflections safely within the console. Only those persons required should be present during servicing and eye protection that safely attenuates the YAG wavelength should be worn by all those present.

5.2 INTERIOR ACCESS & PARTS LOCATION

Interior access is gained through the front cover (door), which is hinged on the right side. Once the front cover is opened, the top cover can be removed. Once the top cover is removed the two side panels can be removed.

Open the front cover to access the DC power supply (mounted inside the door), to access the Controller PCB, or to remove the top cover or either side cover.

To open the front cover, insert a special tool (such as a hex key) through the hole on the bottom left of the front cover. Push up on the tab inside the hole to release the cover (it is hinged on the right side). Refer to Fig. 5.1.

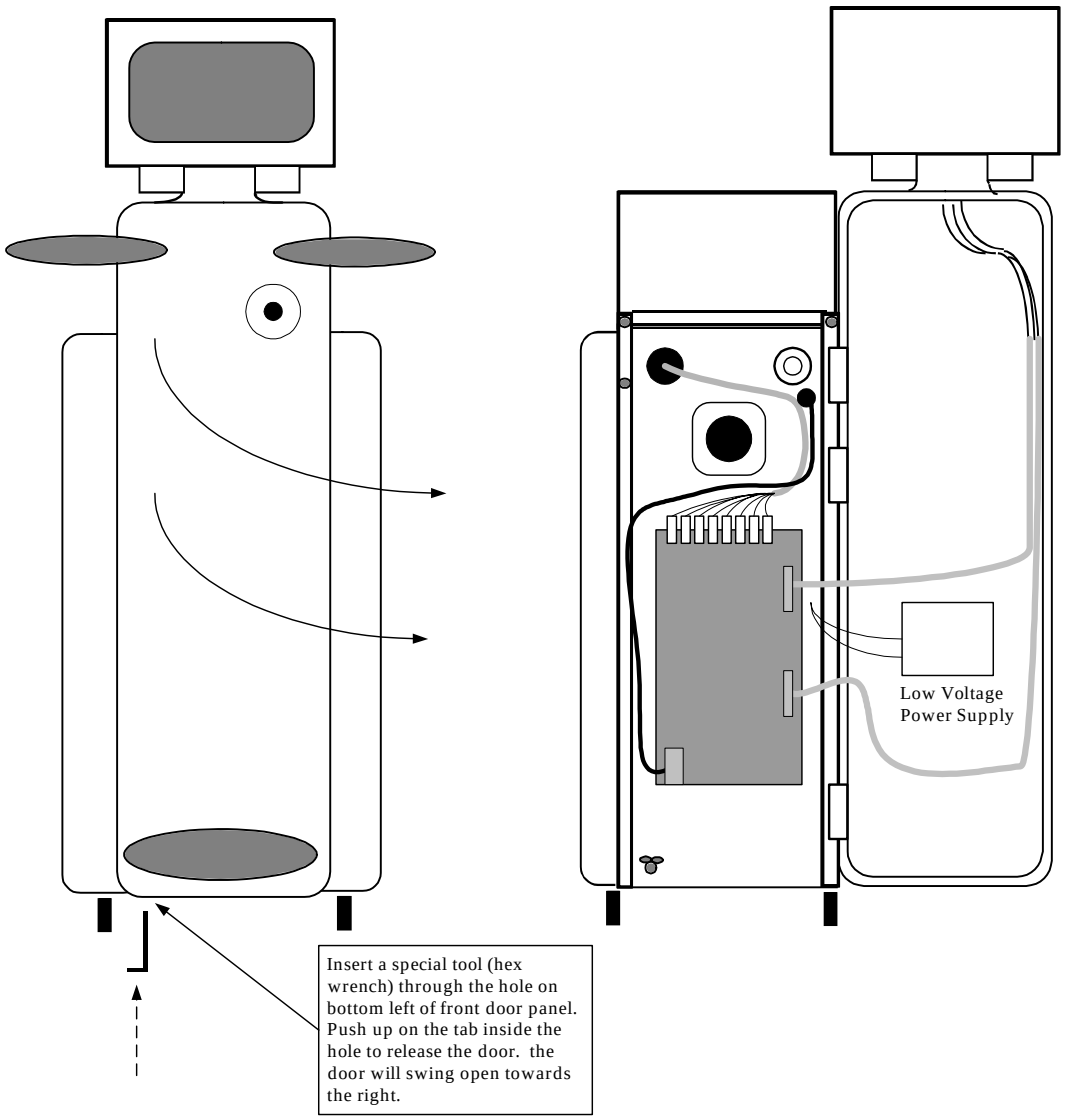

Low Voltage
Power Supply
Insert a special tool (hex wrench) through the hole on bottom left of front door panel. Push up on the tab inside the hole to release the door. the door will swing open towards the right.

FIG. 5.1: FRONT VIEWS

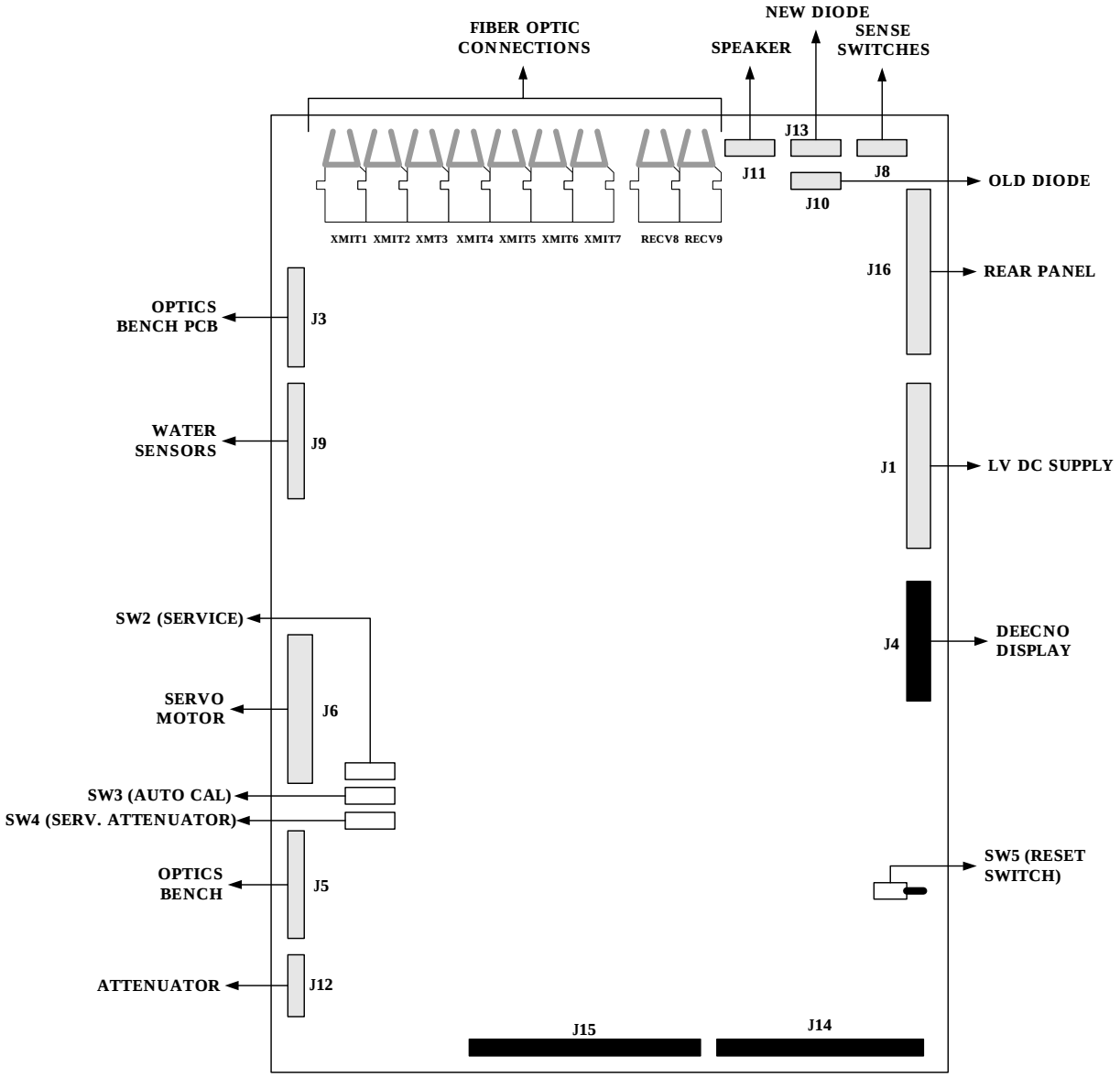


FIG. 5.2: CPU PCB LAYOUT

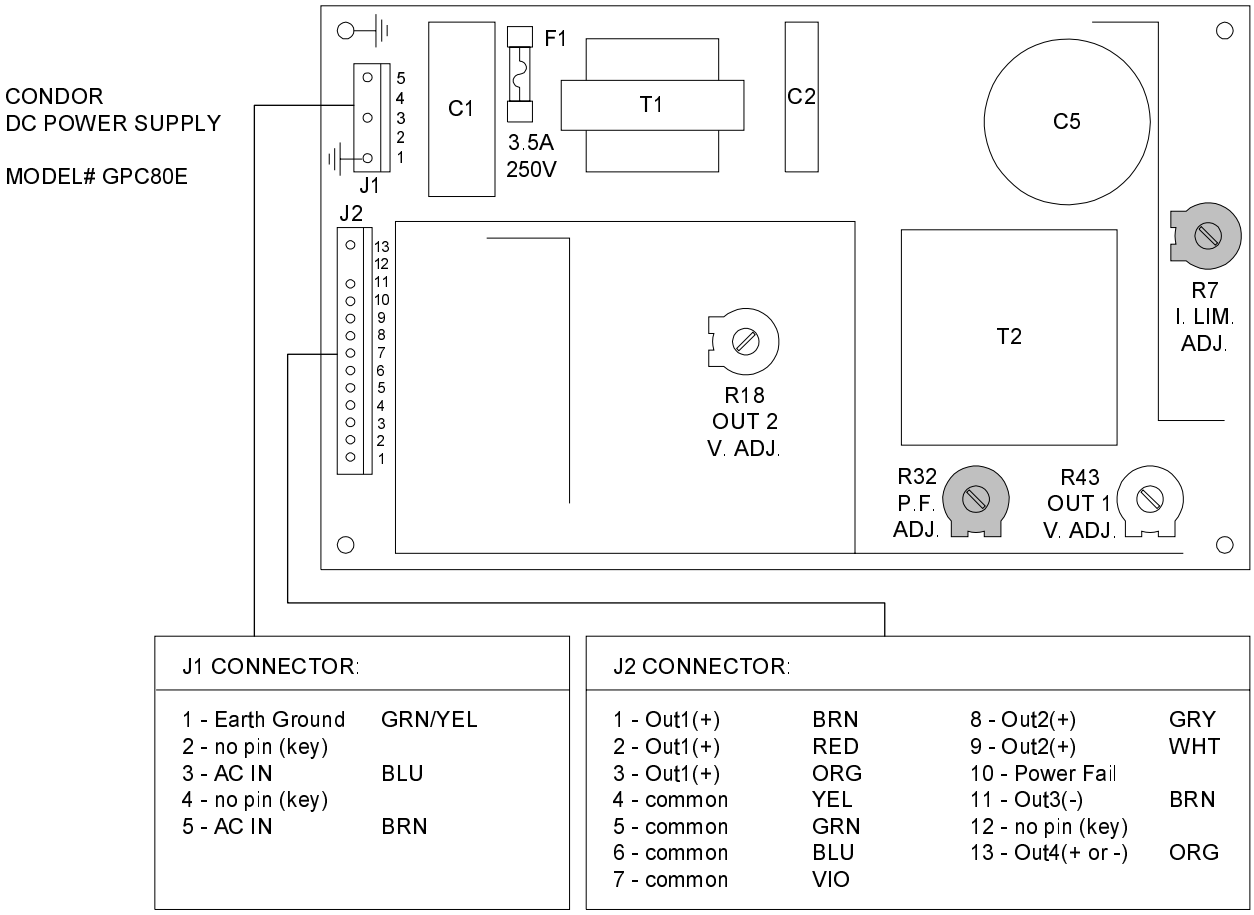


FIG. 5.3: LOW VOLTAGE POWER SUPPLY

Remove the top cover to access the laser head (optics bench), to access the coolant fill reservoir or to remove either side cover.

To remove the top cover, first open the front cover, then remove the two screws located as shown in the drawing on the succeeding pages.

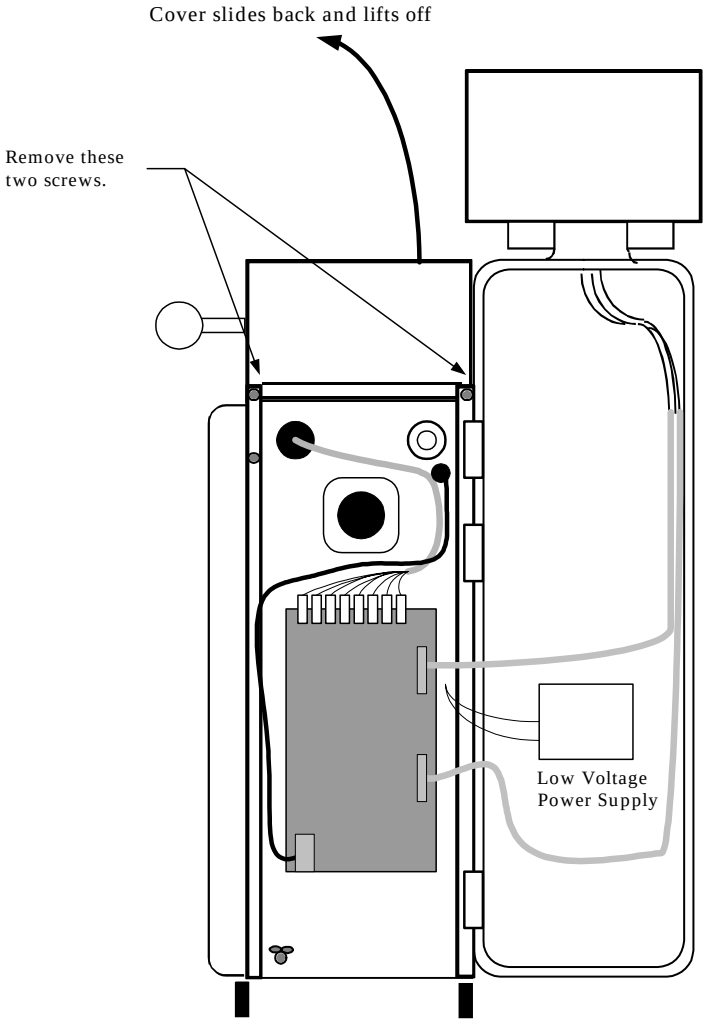
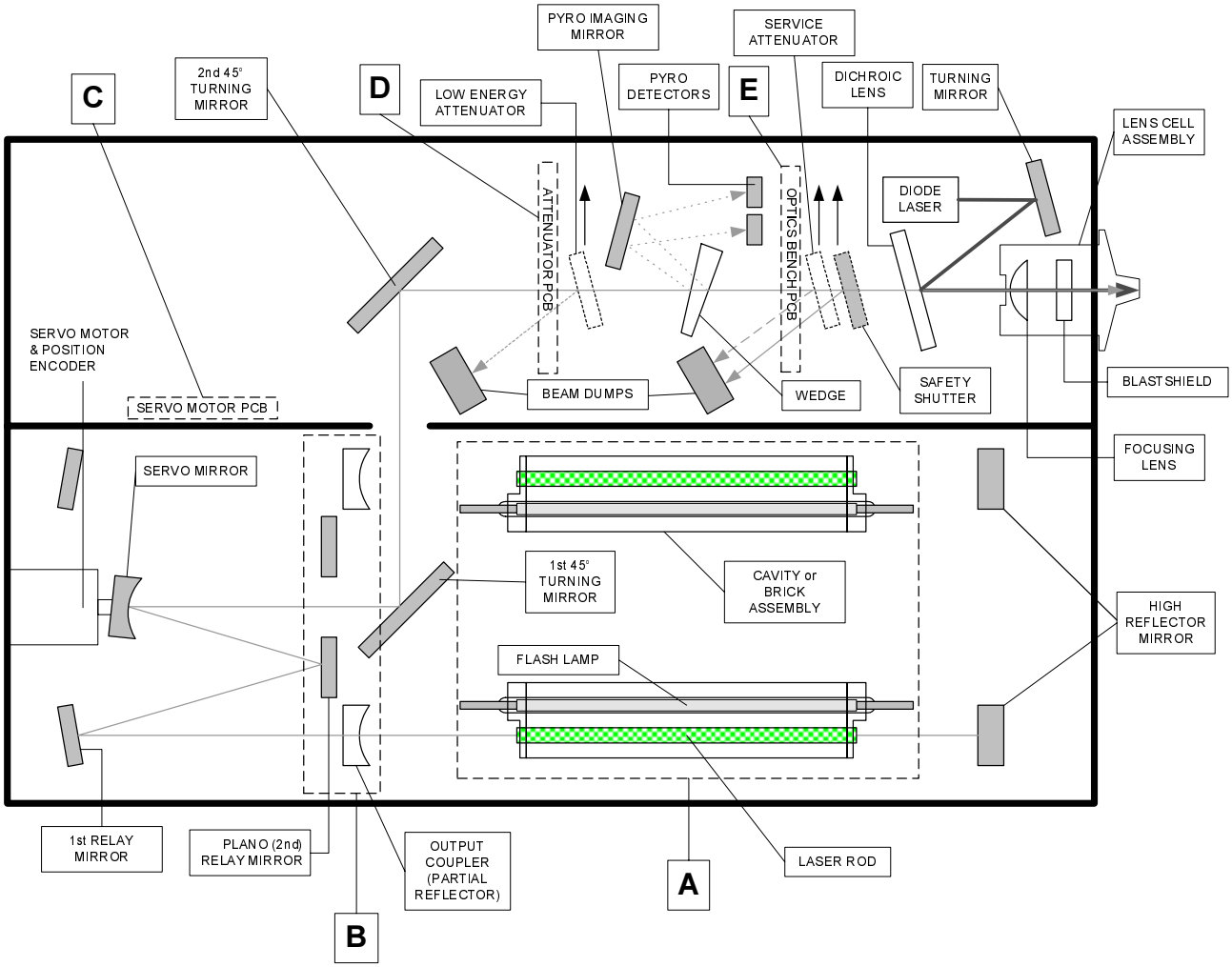


FIG. 5.4: REMOVING THE TOP COVER

Remove optics bench cover to access the Attenuator PCB, Optics Bench PCB, Servo Motor PCB and all of the optical / mechanical components. Removing the cover exposes the optics bench to airborne contamination. The optics that operate on the YAG beam are particularly susceptible to damage associated with optics surface contamination. Remove this cover only when necessary. If the cover must be removed, be careful to minimize exposure of the optics bench interior to external contamination.

To remove the optics bench cover, loosen the screws located along the bottom edge of three sides, then lift the cover up.



The letter key provides a guide to a more detailed diagram / drawing in the succeeding pages.

FIG. 5.5: OPTICS BENCH & LASER HEAD LAYOUT

A

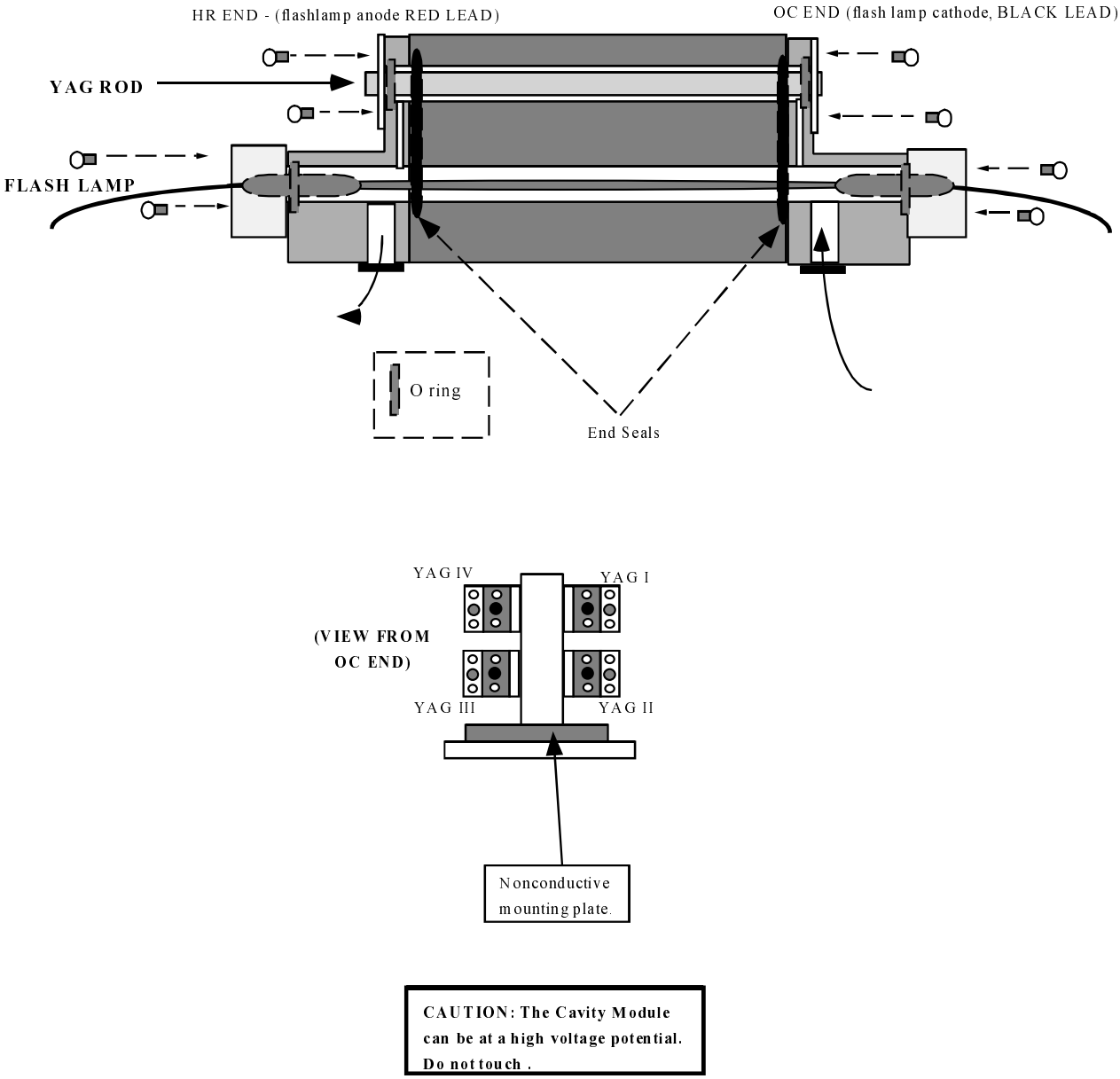

HR END - (flashlamp anode RED LEAD)
OC END (flash lamp cathode, BLACK LEAD)
YAG ROD
FLASH LAMP
O ring
End Seals
YAG IV
YAG I
(VIEW FROM OC END)
YAG III
YAG II
Nonconductive mounting plate.
CAUTION: The Cavity Module can be at a high voltage potential. Do not touch .

FIG. 5.6: YAG CAVITY LAYOUT

B

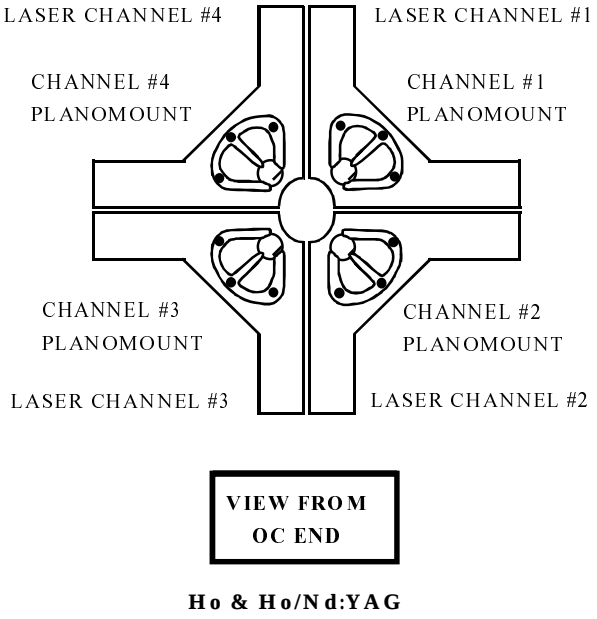


FIG. 5.7

C

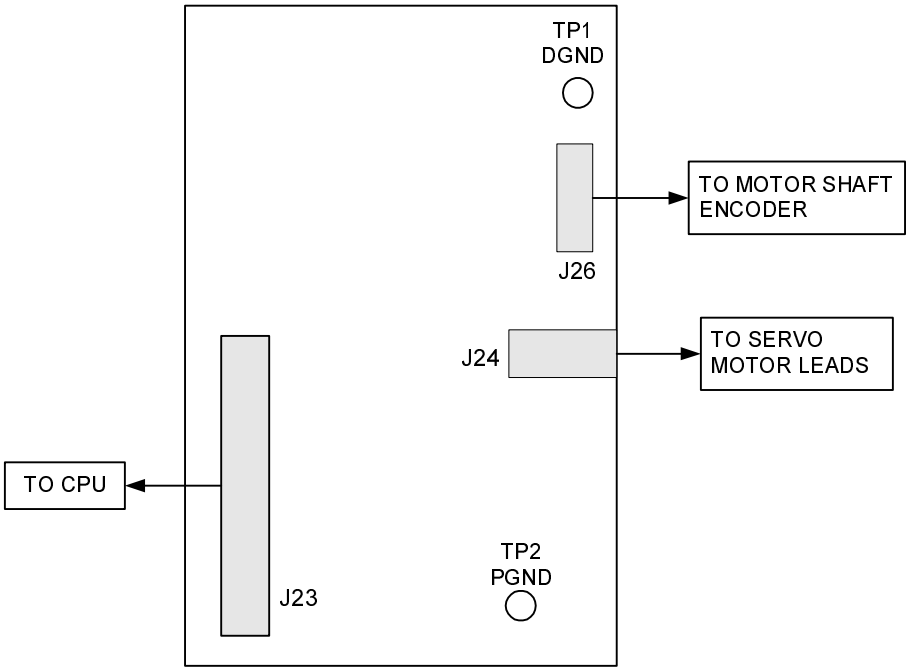


FIG. 5.10
OPTICS
BENCH PCB

FIG. 5.8 SERVO MOTOR PCB

D

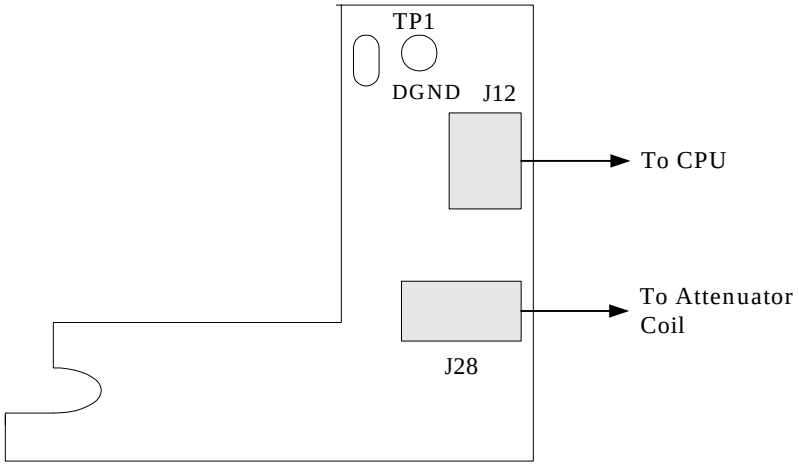
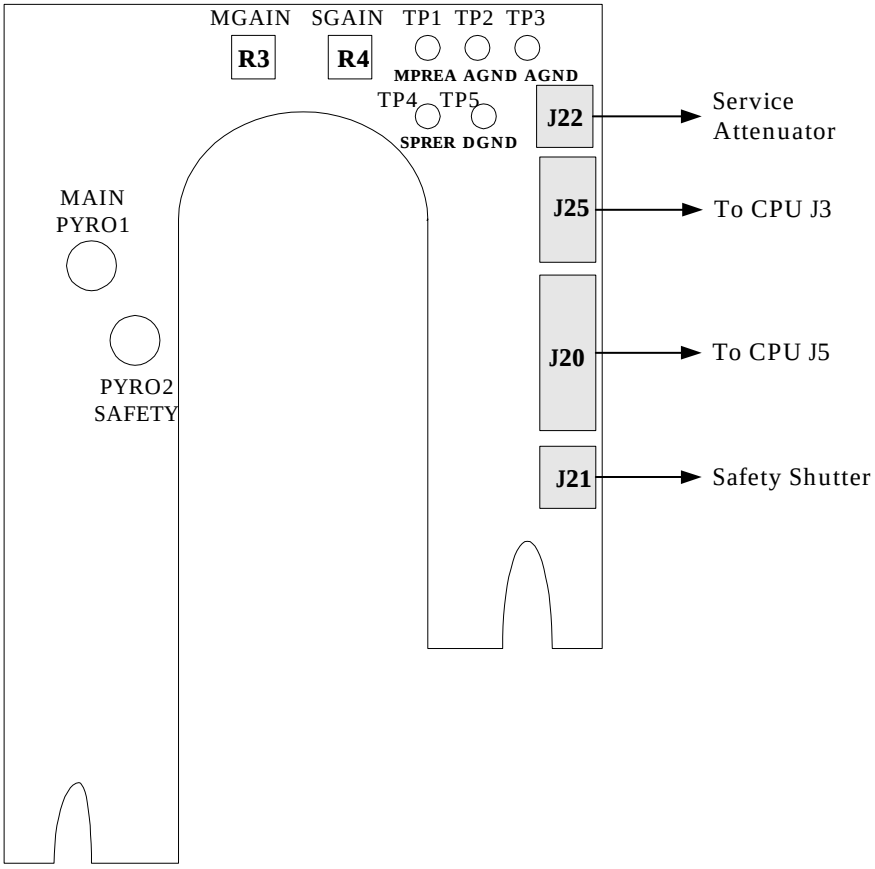


FIG. 5.9 ATTENUATOR PCB

E



Remove the right side cover to access the fuses, AC Control PCB, main contactor, the circuit breaker, HVPS, Tachometer PCB, and to access the interior of the enclosure.

To remove the right side cover, open the front cover, remove the top cover, remove the single screw that secures the cover at the bottom just in front of the rear wheel, then remove the six screws along the top and front of the cover (three along the top, three along the front). The cover can then be lifted off of the frame.

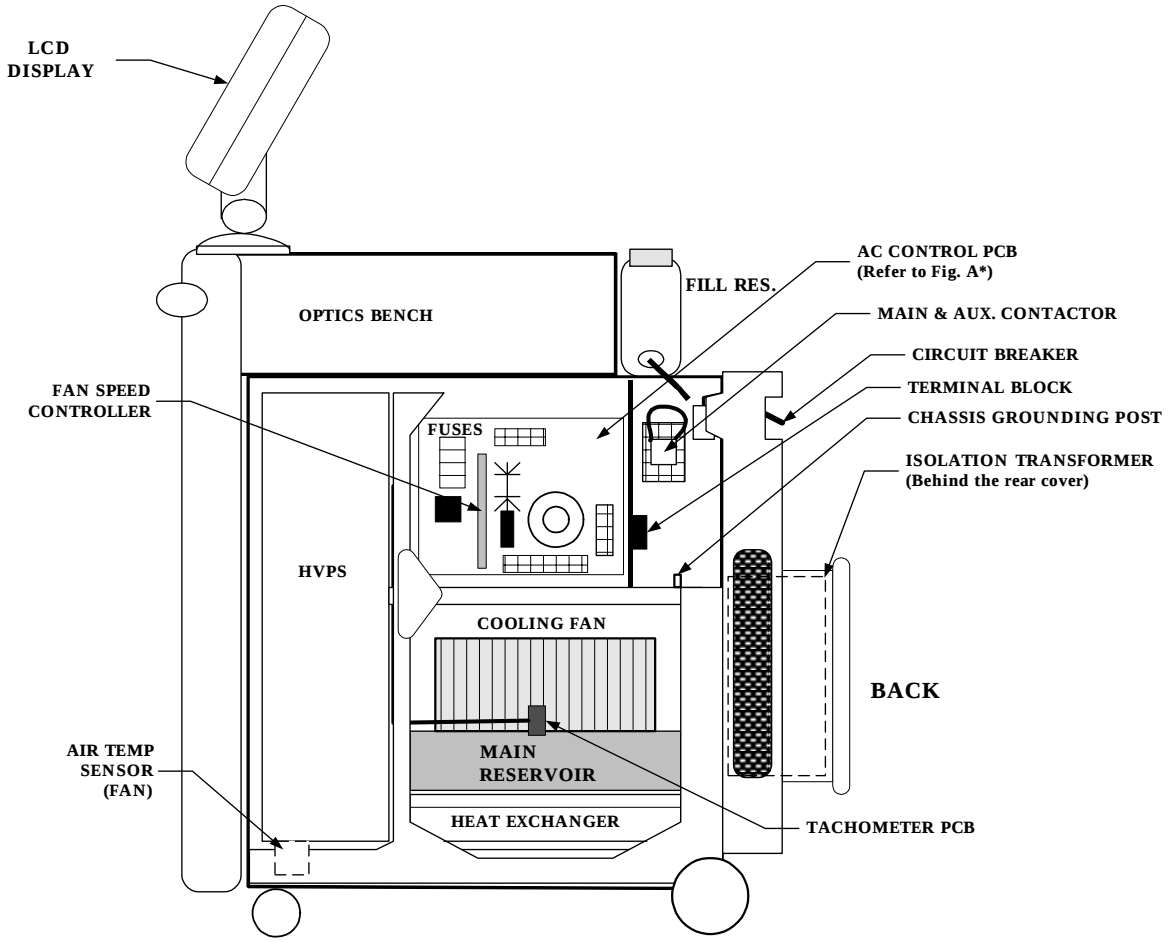


FIG. 5.10: INTERIOR VIEW, RIGHT SIDE

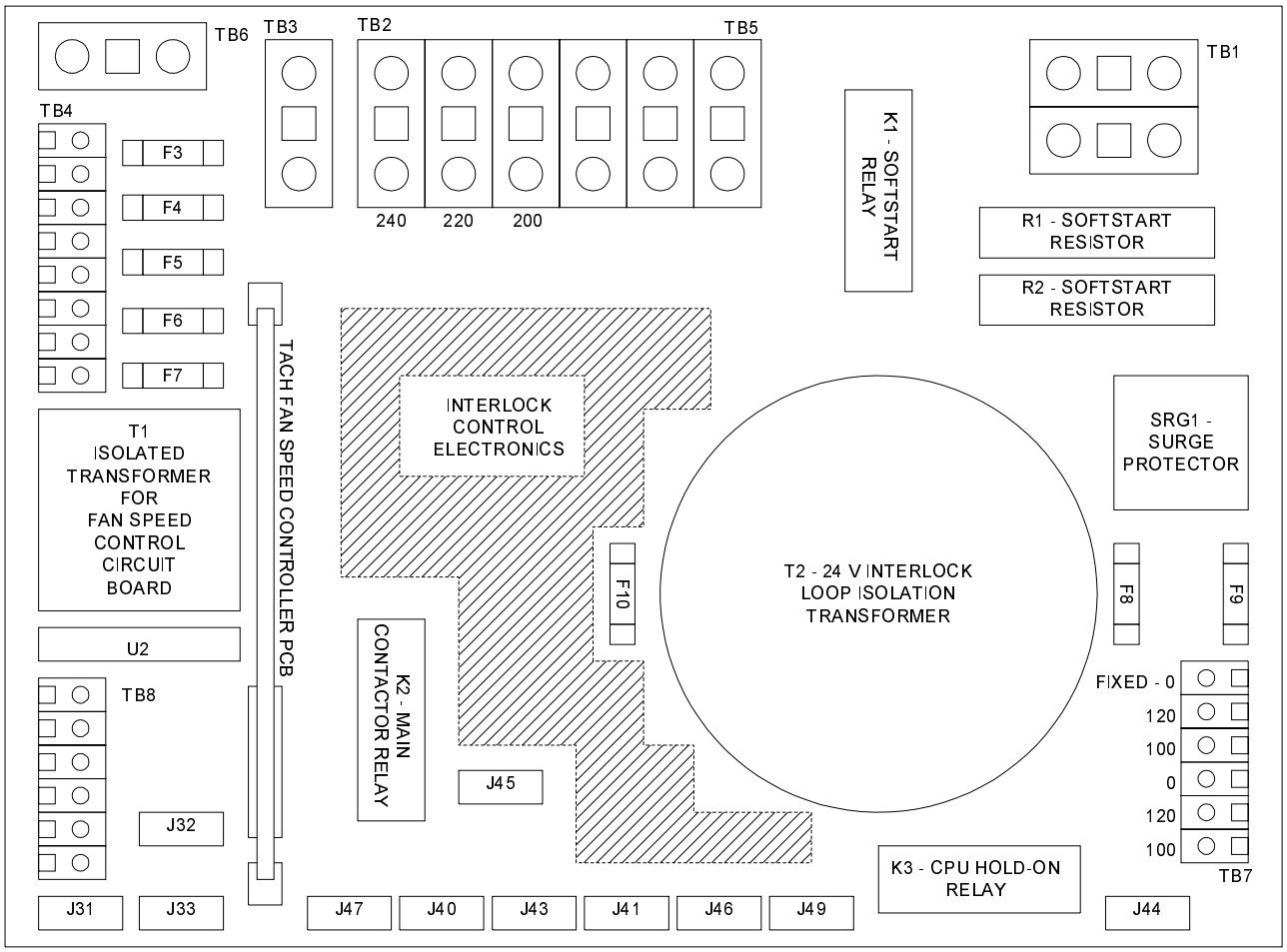


FIG. A*: AC CONTROL PCB LAYOUT

* Refer to Fig. B to view the layout of the Fan Speed Controller PCB.

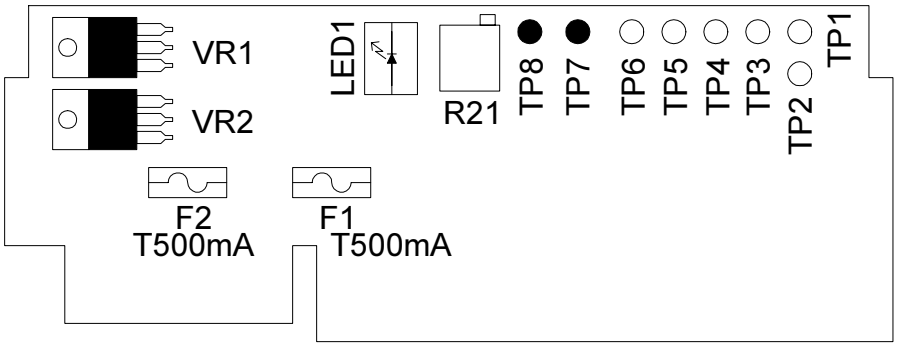


FIG. B: FAN SPEED CONTROLLER PCB

Remove the left side cover to access most of the cooling system components.

To remove the left side cover, open the front cover, remove the top cover, remove the single screw that secures the cover at the bottom, just in front of the rear wheel, remove the six screws along the top and front of the cover (three along the top, three along the front), then carefully pull the cover off.

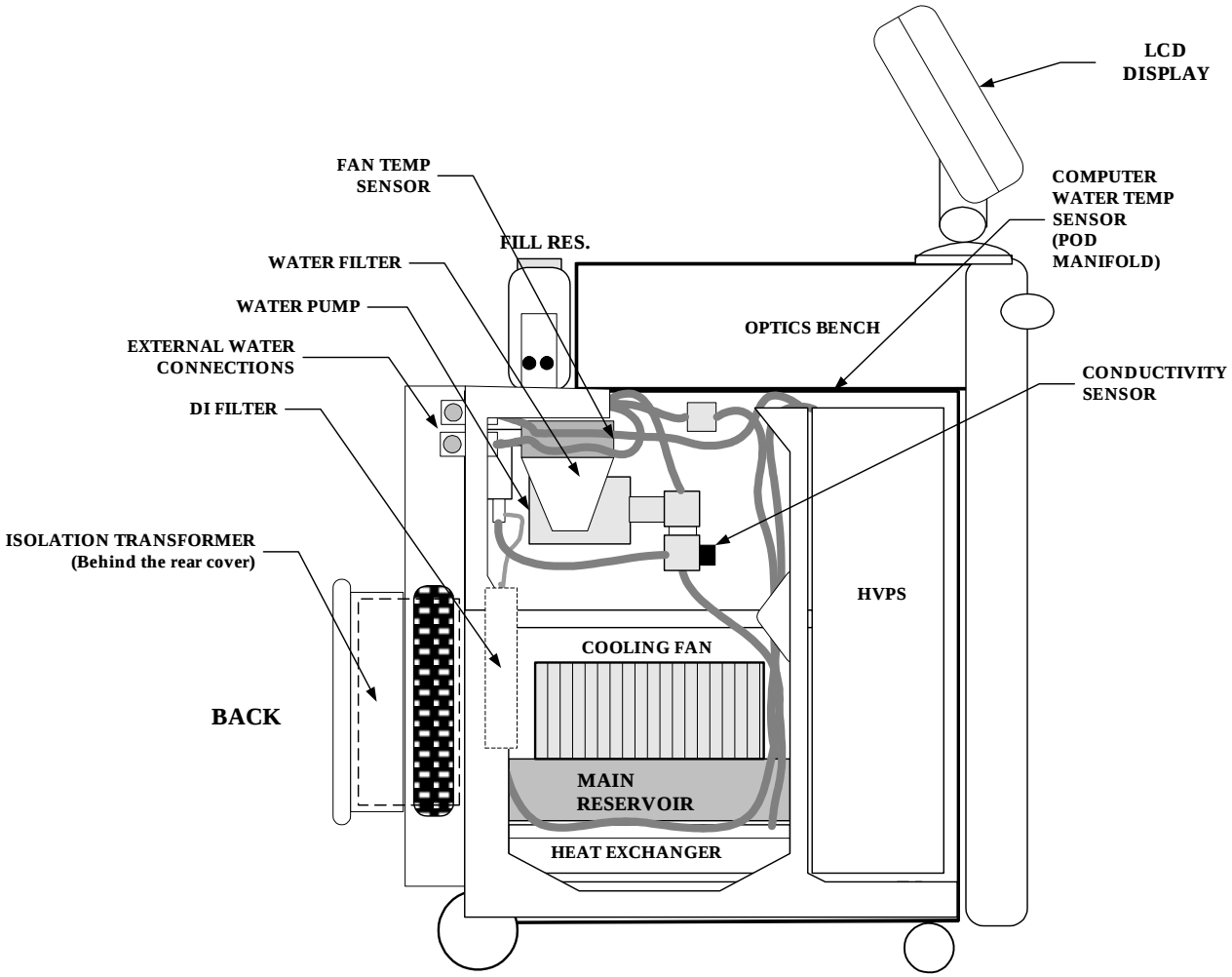


FIG. 5.11: INTERIOR VIEW, LEFT SIDE

5.3 SERVICE MODE

The VersaPulse PowerSuite includes "service mode" software routines. Service mode provides the Servicing Engineer with a number of troubleshooting and maintenance aids, commonly referred to as service screens. Some system faults are ignored in service mode (see 5.4.3).

To enter into service mode, the microprocessor must see an OFF to ON transition of the Controller PCB SW2. SW2 is located on the left side of the Controller PCB. Note that if the switch is left on when the system is powered up, it will not enter into service mode (no OFF to ON transition). If the microprocessor is halted (some faults are handled by halting the microprocessor) the service switch will not work - restart the microprocessor (press the reset switch SW5 on the Controller PCB) then toggle the service switch OFF to ON.

The following are illustrations of the different service screens when the system is in service mode:

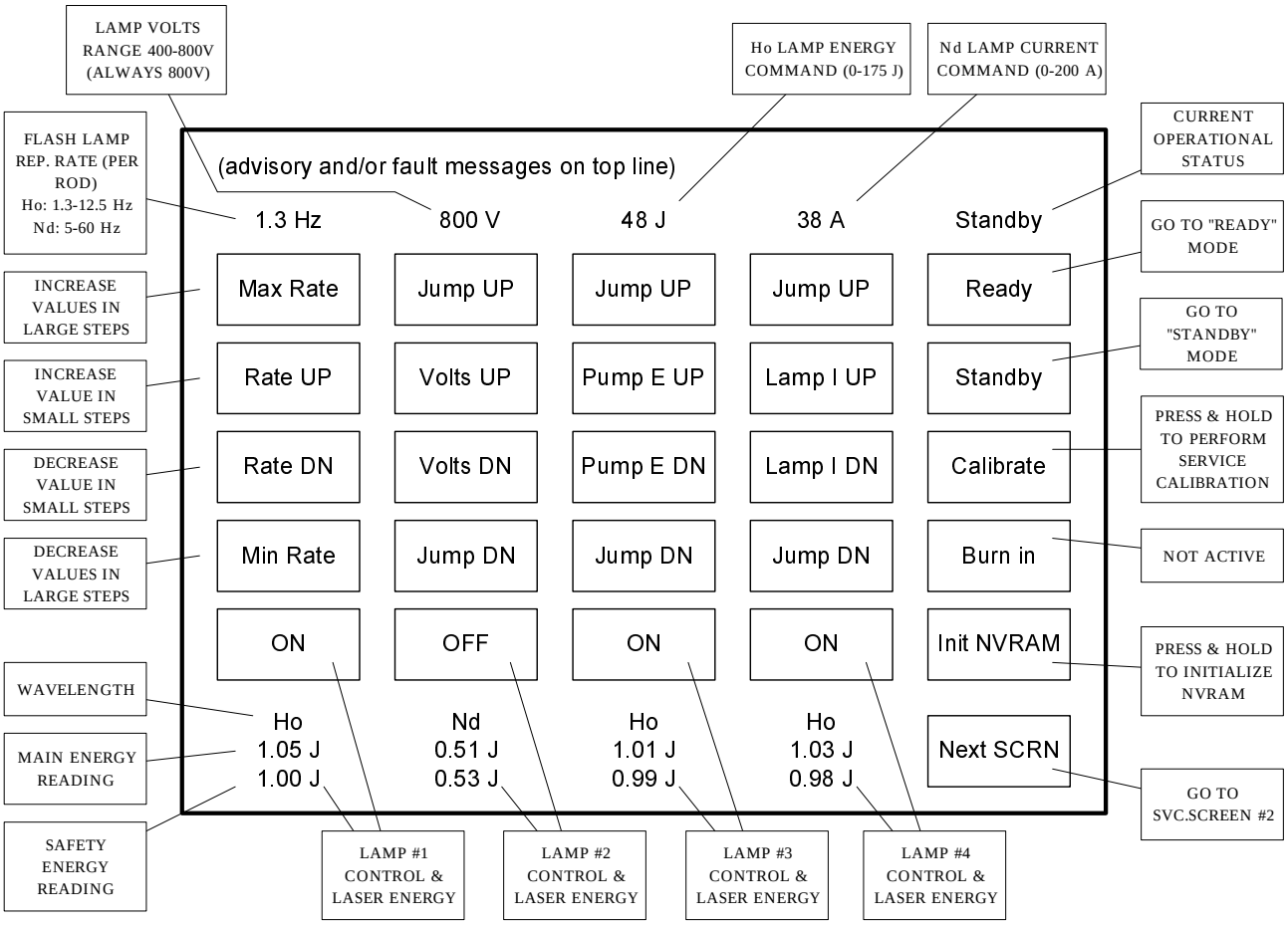


FIG. 5.12: FIRST SERVICE SCREEN

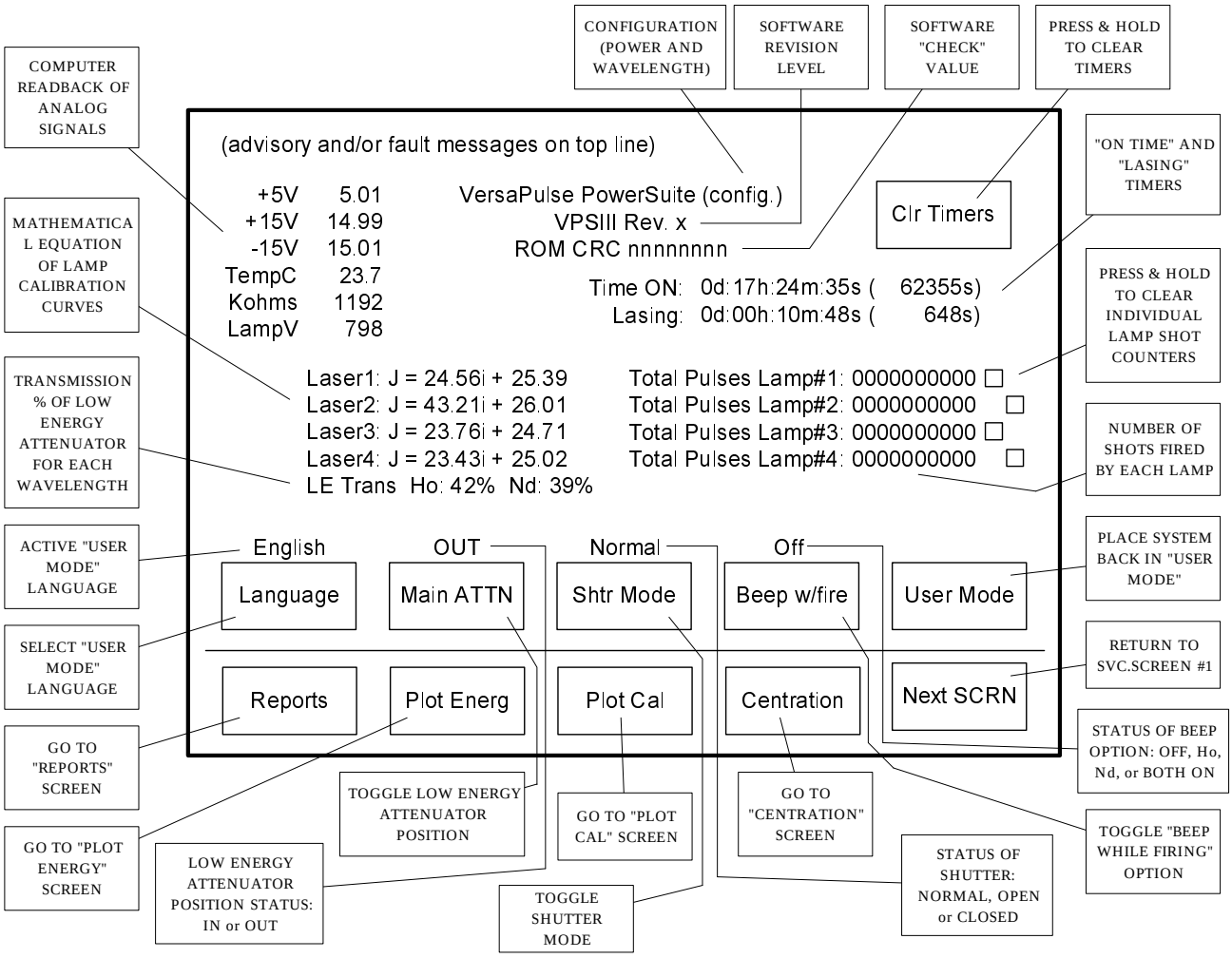

CONFIGURATION (POWER AND WAVELENGTH)
SOFTWARE REVISION LEVEL
SOFTWARE "CHECK" VALUE
PRESS & HOLD TO CLEAR TIMERS
COMPUTER READBACK OF ANALOG SIGNALS
"ON TIME" AND "LASING" TIMERS
(advisory and/or fault messages on top line)
+5V 5.01
+15V 14.99
-15V 15.01
TempC 23.7
Kohms 1192
LampV 798
VersaPulse PowerSuite (config.)
VPSIII Rev. x
ROM CRC nnnnnnnn
Clr Timers
Time ON: 0d:17h:24m:35s (62355s)
Lasing: 0d:00h:10m:48s (648s)
MATHEMATICAL EQUATION OF LAMP CALIBRATION CURVES
PRESS & HOLD TO CLEAR INDIVIDUAL LAMP SHOT COUNTERS
Laser1: J = 24.56i + 25.39
Laser2: J = 43.21i + 26.01
Laser3: J = 23.76i + 24.71
Laser4: J = 23.43i + 25.02
Total Pulses Lamp#1: 0000000000
Total Pulses Lamp#2: 0000000000
Total Pulses Lamp#3: 0000000000
Total Pulses Lamp#4: 0000000000
TRANSMISSION % OF LOW ENERGY ATTENUATOR FOR EACH WAVELENGTH
NUMBER OF SHOTS FIRED BY EACH LAMP
LE Trans Ho: 42% Nd: 39%
ACTIVE "USER MODE" LANGUAGE
English
OUT
Normal
Off
PLACE SYSTEM BACK IN "USER MODE"
Language
Main ATTN
Shtr Mode
Beep w/fire
User Mode
SELECT "USER MODE" LANGUAGE
RETURN TO SVC.SCREEN #1
Reports
Plot Energ
Plot Cal
Centration
Next SCRN
GO TO "REPORTS" SCREEN
STATUS OF BEEP OPTION: OFF, Ho, Nd, or BOTH ON
TOGGLE LOW ENERGY ATTENUATOR POSITION
GO TO "PLOT CAL" SCREEN
GO TO "CENTRATION" SCREEN
GO TO "PLOT ENERGY" SCREEN
TOGGLE "BEEP WHILE FIRING" OPTION
LOW ENERGY ATTENUATOR POSITION STATUS: IN or OUT
TOGGLE SHUTTER MODE
STATUS OF SHUTTER: NORMAL, OPEN or CLOSED

FIG. 5.13: SECOND SERVICE SCREEN

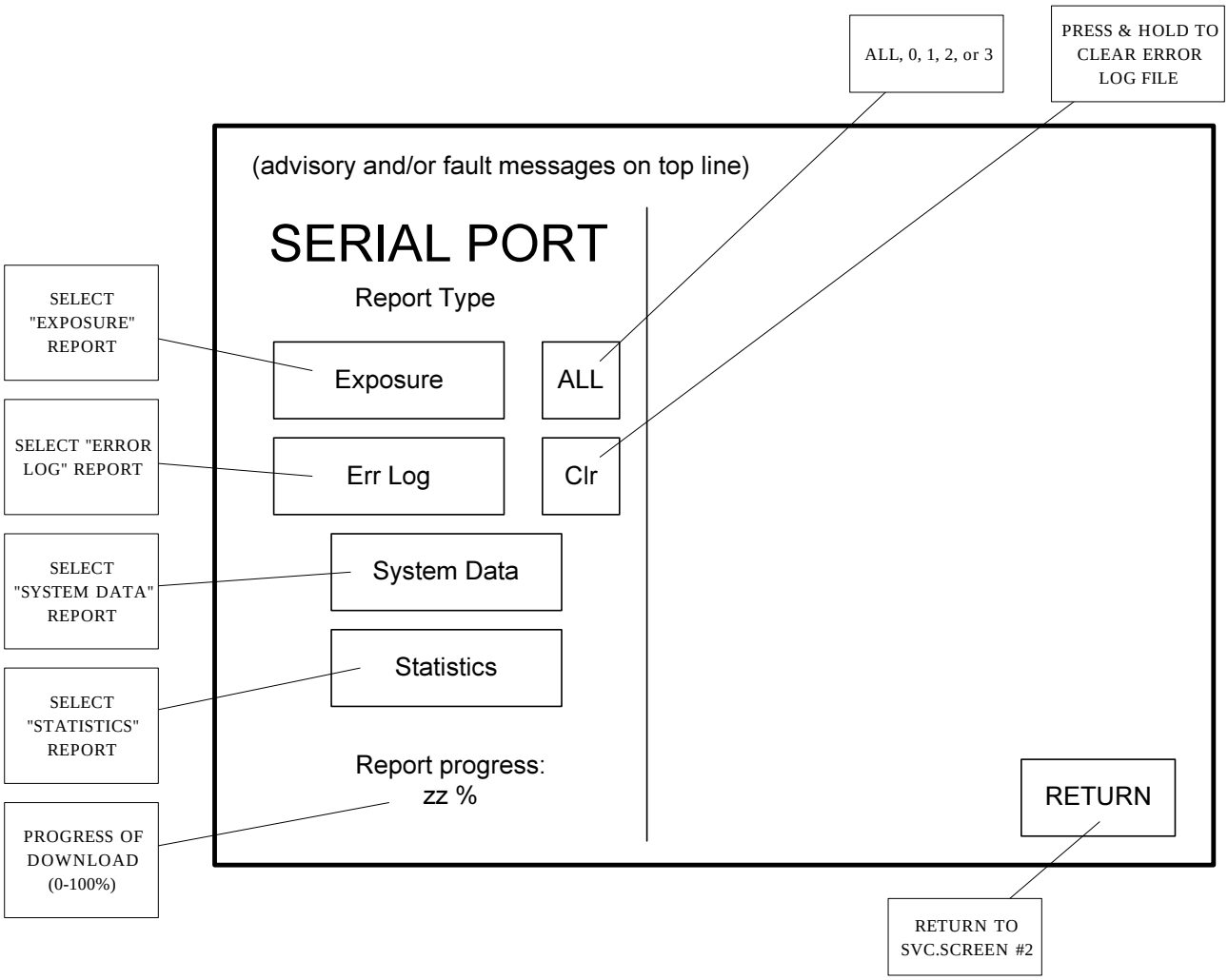


FIG. 5.14: THIRD SERVICE SCREEN (REPORT SCREEN)

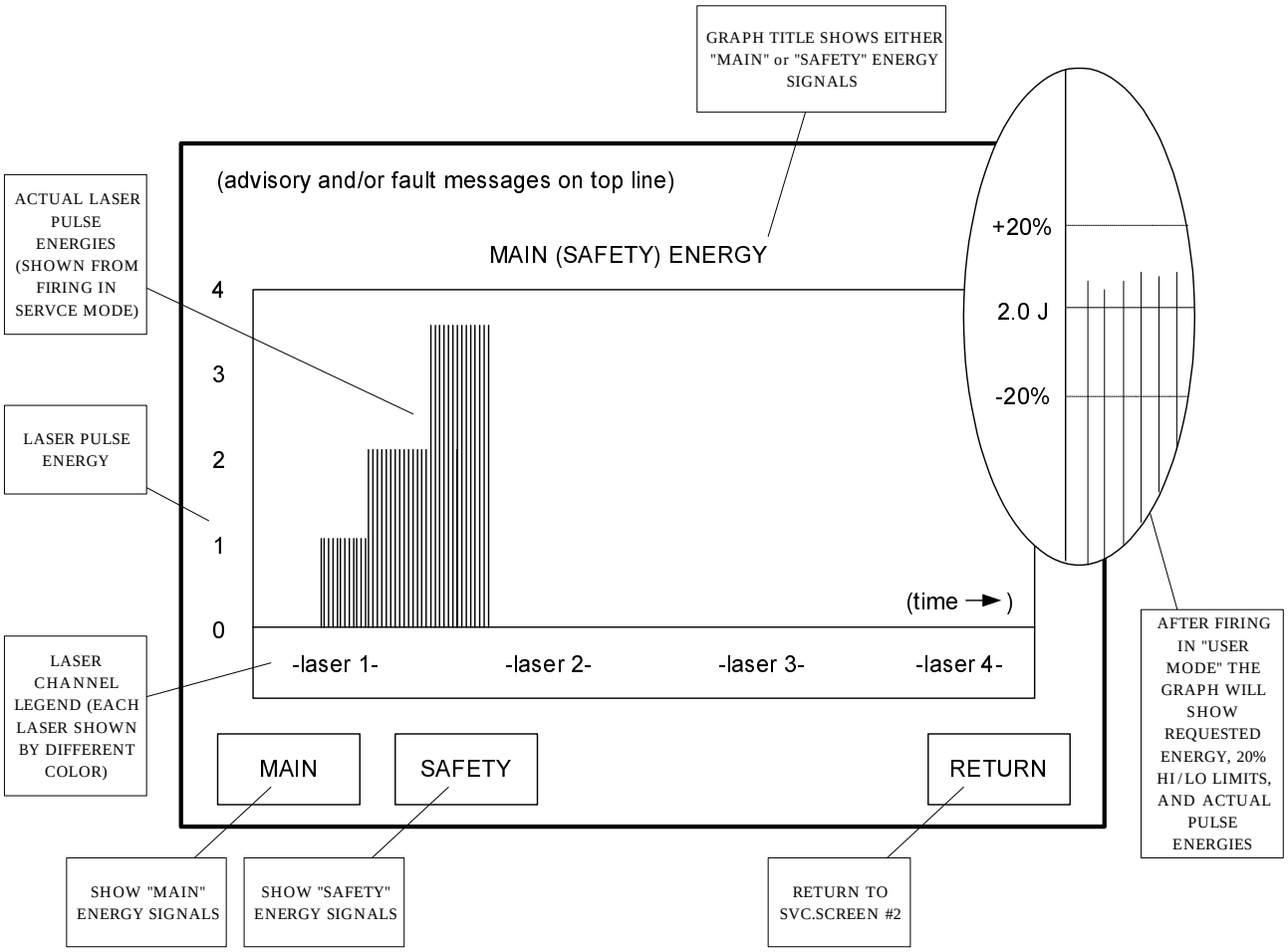


FIG. 5.15: FOURTH SERVICE SCREEN (PLOT ENERGY SCREEN)

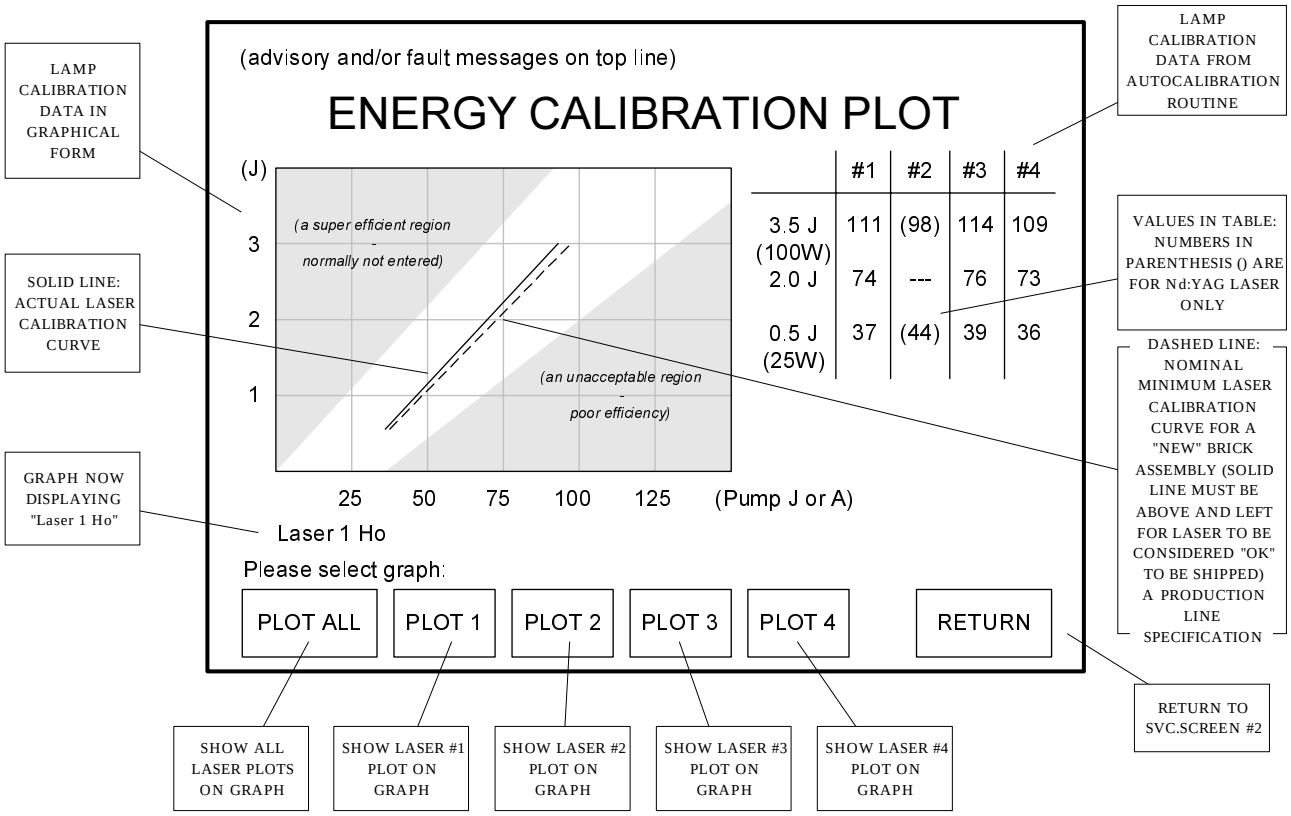

LAMP CALIBRATION DATA IN GRAPHICAL FORM
SOLID LINE: ACTUAL LASER CALIBRATION CURVE
GRAPH NOW DISPLAYING "Laser 1 Ho"
(advisory and/or fault messages on top line)
ENERGY CALIBRATION PLOT
(J)
3
2
1
(a super efficient region - normally not entered)
(an unacceptable region - poor efficiency)
25 50 75 100 125 (Pump J or A)
Laser 1 Ho
Please select graph:
PLOT ALL
PLOT 1
PLOT 2
PLOT 3
PLOT 4
RETURN
LAMP CALIBRATION DATA FROM AUTOCALIBRATION ROUTINE
#1 #2 #3 #4
3.5 J (100W) 111 (98) 114 109
2.0 J 74 --- 76 73
0.5 J (25W) 37 (44) 39 36
VALUES IN TABLE: NUMBERS IN PARENTHESIS () ARE FOR Nd:YAG LASER ONLY
DASHED LINE: NOMINAL MINIMUM LASER CALIBRATION CURVE FOR A "NEW" BRICK ASSEMBLY (SOLID LINE MUST BE ABOVE AND LEFT FOR LASER TO BE CONSIDERED "OK" TO BE SHIPPED) A PRODUCTION LINE SPECIFICATION
RETURN TO SVC.SCREEN #2
SHOW ALL LASER PLOTS ON GRAPH
SHOW LASER #1 PLOT ON GRAPH
SHOW LASER #2 PLOT ON GRAPH
SHOW LASER #3 PLOT ON GRAPH
SHOW LASER #4 PLOT ON GRAPH

FIG. 5.16: FIFTH SERVICE SCREEN (PLOT CAL SCREEN)

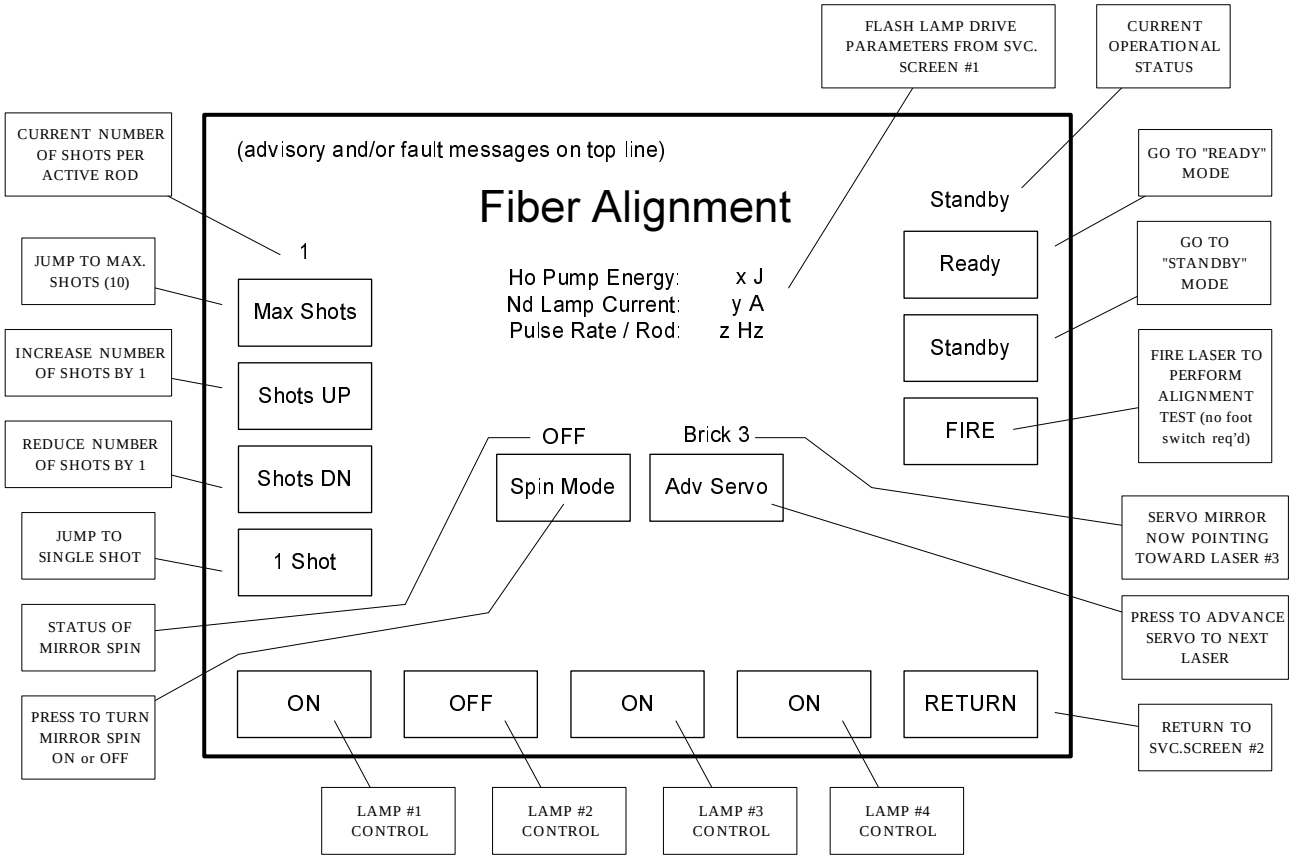


FIG. 5.17: SIXTH SERVICE SCREEN (CENTRATION SCREEN)

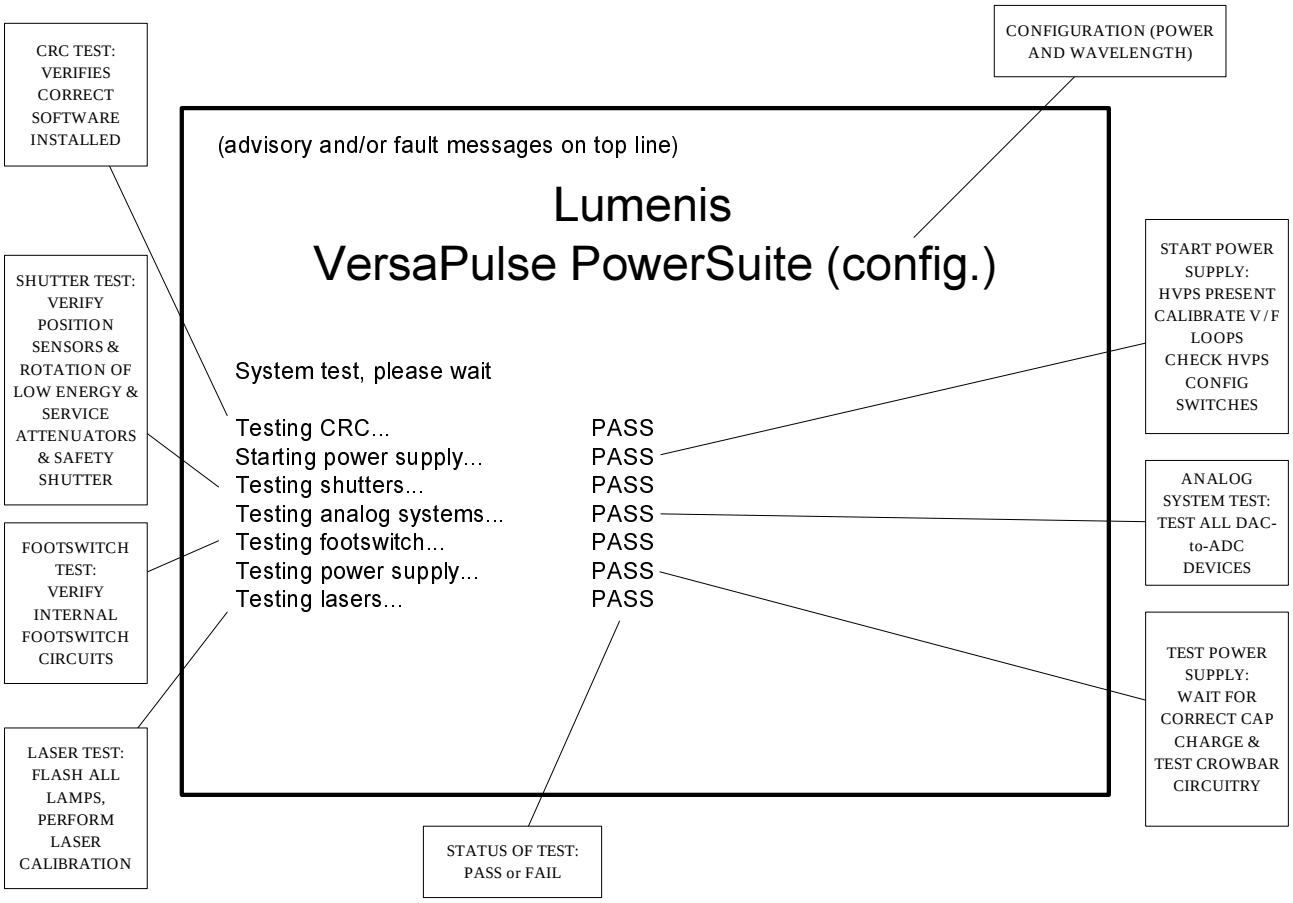

CRC TEST: VERIFIES CORRECT SOFTWARE INSTALLED
CONFIGURATION (POWER AND WAVELENGTH)
(advisory and/or fault messages on top line)
Lumenis
VersaPulse PowerSuite (config.)
START POWER SUPPLY: HVPS PRESENT CALIBRATE V/F LOOPS CHECK HVPS CONFIG SWITCHES
SHUTTER TEST: VERIFY POSITION SENSORS & ROTATION OF LOW ENERGY & SERVICE ATTENUATORS & SAFETY SHUTTER
System test, please wait
Testing CRC... PASS
Starting power supply... PASS
Testing shutters... PASS
Testing analog systems... PASS
Testing footswitch... PASS
Testing power supply... PASS
Testing lasers... PASS
ANALOG SYSTEM TEST: TEST ALL DAC-to-ADC DEVICES
FOOTSWITCH TEST: VERIFY INTERNAL FOOTSWITCH CIRCUITS
TEST POWER SUPPLY: WAIT FOR CORRECT CAP CHARGE & TEST CROWBAR CIRCUITRY
LASER TEST: FLASH ALL LAMPS, PERFORM LASER CALIBRATION
STATUS OF TEST: PASS or FAIL

FIG. 5.18: SEVENTH SERVICE SCREEN (POWER-UP SCREEN)

5.4 FAULT ISOLATION

Failures / malfunctions fall into the following general categories:

The system fails to turn on properly, or shuts off when it should not. See section 5.4.1.

The system turns on, but the Control Panel displays and / or operating controls do not respond properly, and no fault code is displayed. See section 5.4.2

During power up tests, or during operation, the system displays one or more error codes. See section 5.4.3.

During power up self tests the system fails to pass autocalibration See Section 5.4.4

5.4.1 Turn On and Shut Down Fault Isolation

System "turn-on" problems occur when the system fails to turn on and stay on with activation of the key switch. System "Shutdown" refers to the system main contactor de-energizing after the system has successfully turned on.

If the system fails to turn on, determine if there is power to the unit and through the circuit breaker to the main contactor and isolation transformer. Determine if the main contactor is energizing when the keyswitch is held in the start position (do the system fan and pump start running?). If not, check the circuit breaker, isolation transformer thermal switch and fuses F8/F9. If the contactor is energizing in the start position, but de-energizing when the keyswitch is released, check for sufficient coolant flow (coolant level, pump, line restrictions, etc.), waterflow switch S3, K2 and K1 (Refer to Interlock schematic in Section 8).

If the system shuts down after being turned on, and the circuit breaker is not tripping, use the Interlock schematic in Section 8 to troubleshoot the main contactor interlock loop. Note that the software and microprocessor can turn off the main contactor. The 24 VAC loop to the main contactor can be broken by the thermal switch in the isolation transformer, the waterflow switch, hold on relay K3, or the fuse F10.

If the circuit breaker is tripping, check for proper transformer tapping. If the tripping is associated with firing (or charging of the main capacitor), it is probably associated with the HVPS. If not, attempt to isolate the tripping to one of the isolation transformer secondary loads by removing fuses until the circuit breaker no longer trips (smart fan fuse, pump fuse, display P/S fuse, then interlock loop fuse).

5.4.2 "No Fault Code Reported" Fault Isolation

Some system malfunctions cannot be reported at the Control Panel. These include those malfunctions which interfere with the operation of the microprocessor, malfunctions in the hardware that drives the display used to report errors, and miscellaneous circuits/functions which are not directly monitored/tested by the software.

If the malfunction is associated with a particular function (e.g., the system doesn't respond to the footswitch, or to some front panel control), troubleshoot that function, referring to the circuit descriptions in Section 4.

If the system turns on, but the malfunction is more general (e.g., the self test sequence doesn't run, Control Panel does not respond) check for proper DC power supply voltages, isolation transformer tapping, interconnection problems, or for some problem with the microprocessor (are they running?)/Control Panel interface. If the problem can not be isolated to a particular circuit, replace the CPU PCB.

5.4.3 "Fault Code Reported" Fault Isolation

The microprocessor monitors the system to detect and respond to various fault conditions. When a fault is detected, the microprocessor displays the fault directly on the CPU PCB (as a four digit message). The microprocessor updates the touch screen to display the fault code and any accompanying message at the touch screen. Multiple faults are displayed sequentially, and repeatedly.

These fault conditions can be informational, clearable, or permanent.

Informational faults notify the user of some detected abnormal condition that is not significant enough to interfere with system operation. An advisory message is displayed on the touch screen and the system continues to operate.

Clearable faults interrupt system operation and force the system to STANDBY, but have the potential to be cleared by some user action. Some clearable faults include messages to indicate an action required by the user, e.g., "ATTACH FIBER" appears on the touch screen if there is no fiber attached. Other clearable faults advise of some detected abnormal condition, but require no further action by the user other than selecting READY to clear the error. Finally, the coolant resistivity and overtemperature errors will not clear until that parameter falls back into acceptable limits. The user can't clear these faults directly. Note that a clearable fault will return if the condition that caused it occurs again or is still active.

Permanent faults place the system in a safe, non-firing condition that can not be cleared without restarting the system. Restarting the system will clear the fault, but if the detected condition is still present, the fault will occur again.

Some faults are ignored in service mode to aid in troubleshooting. Some faults are only checked during the self test sequence that occurs at start up. Such faults are so identified in the description of the fault.

Begin by getting a detailed understanding of the symptoms. For example, does the fault appear during self testing or during normal operation; Does the fault occur only when firing; Only at certain energy or pulse settings; is the fault easily repeatable or is it intermittent? It is always worthwhile to check for proper mains input, proper transformer tapping, proper DC voltage supply outputs, and to perform a careful visual inspection for loose connections and visual indications of problems.

The following list defines the fault codes / messages and provides troubleshooting information for each.

A: How Cleared: P = Permanent; R = Press Ready to Clear
B: Error Recognized in Service Mode: Y = Yes; N = No

Code	Fault Displayed	A	B	Description
11	Fault 11	P	Y	A / D converter test failed.
12	Fault 12	P	N	A / D converter #1 failed to finish conversion within 50µS.
13	Fault 13	P	N	A / D converter #2 failed to finish conversion within 50µS.
21	Fault 21	P	N	Servo motor controller failed to respond.
31	Fault 31	P	N	Servo motor failed to find home position.
51	Fault 51	R	N	Service serial port failed to respond within designated time.
52	Fault 52	R	N	Main panel failed to respond within designated time.
53	Fault 53	R	N	Remote failed to respond within designated time.
102	Fault 102	P	Y	System ROM has wrong CRC.
103	Fault 103	P	Y	Internal data has failed to validate.
104	Fault 104	P	Y	Program flow is incorrect.
105	Fault 105	P	N	System is not calibrated.
201	Fault 201	P	N	Shutter test failed.
202	Fault 202	R	N	Shutter failed to block the beam.
203	Fault 203	R	N	Shutter failed to unblock the beam.
204	Fault 204	P	N	Both optocouplers for the shutter see light.

205	Fault 205	P	N	Neither optocouplers for the shutter sees light.
211	Fault 211	P	N	Attenuator test failed.
212	Fault 212	R	N	Attenuator is in the beam path when it should not be.
213	Fault 213	R	N	Attenuator is out of the beam path when it should be.
221	Fault 221	P	N	Service Attenuator test failed.
222	Fault 222	R	Y	Service attenuator is in the beam path when it should not be.
223	Fault 223	R	Y	Service attenuator is out of the beam path when it should not be.
303	Energy High	R	N	Pulse energy is over 50% higher than requested.
304	Energy Low	R	N	Pulse energy is over 50% lower than requested.
351	Rate 20% High	R	N	Rate is more than 20% higher than requested.
352	Rate 20% Low	R	N	Rate is more than 20% lower than requested.
401	Check Footswitch	R	N	Footswitch #1 is depressed.
402	Fault 402	P	Y	Footswitch interface for footswitch #1 failed test.
403	Fault 403	R	Y	Footswitch #1 contacts are bouncing.
404	Attach footswitch	R	Y	Footswitch #1 is disconnected - both contacts are open.
405	Fault 405	R	Y	Footswitch #1 contacts are both closed.
406	Fault 406	R	Y	Footswitch #1 internal logic failed.
421	Check Footswitch	R	N	Footswitch #2 is pressed down.

422	Fault 422	P	Y	Footswitch interface for footswitch #2 failed test.
423	Fault 423	R	Y	Footswitch #2 contacts are bouncing.
424	Fault 424	R	Y	Footswitch #2 is disconnected.
425	Fault 425	R	Y	Footswitch #2 contacts are both closed.
426	Fault 426	R	Y	Footswitch #2 internal logic failed.
431	Check Interlock	R	N	External interlock plug is removed.
441	Insert Debris Shield	R	N	Debris shield is removed from the system.
451	Attach Fiber	R	N	No delivery fiber is connected or fiber is disconnected from the system.
501	Fault 501	P	Y	No power to High Voltage Power Supply.
502	Fault 502	P	Y	HVPS fiber interface calibration failed.
503	Fault 503	P	Y	HVPS modulation calibration failed.
504	Fault 504	P	Y	HVPS crowbar test failed.
505	Fault 505	R	Y	Voltage on HVPS capacitor bank is outside specification.
510	Fault 510	P	Y	Channel 0 of the HVPS is configured incorrectly.
511	Fault 511	P	Y	Channel 1 of the HVPS is configured incorrectly.
512	Fault 512	P	Y	Channel 2 of the HVPS is configured incorrectly.
513	Fault 513	P	Y	Channel 3 of the HVPS is configured incorrectly.
514	Fault 514	R	Y	Crowbar is active.

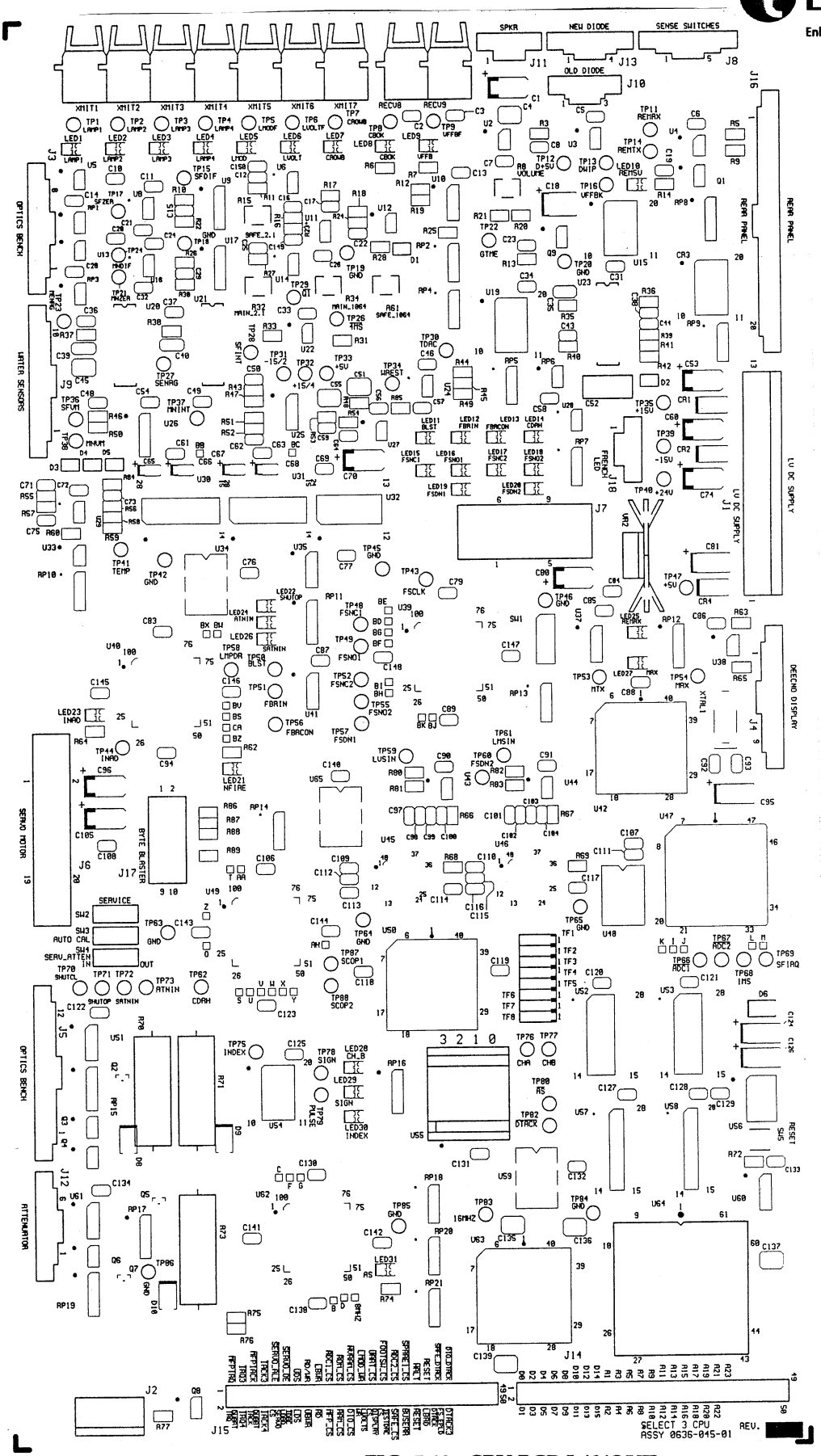


FIG. 5.19: CPU PCB LAYOUT

601	Fault 601	R	Y	+5 VDC is out of specification.
602	Fault 602	R	Y	+15 VDC is out of specification
603	Fault 603	R	Y	-15 VDC is out of specification
701	Fault 701	R	N	Coolant temperature too high.
702	Fault 702	R	N	Coolant temperature too low.
703	Fault 703	R	N	Coolant conductivity too high.
801	Fault 801	P	N	Inadvertent exposure test failed.
802	Fault 802	R	N	Inadvertent exposure.
803	Fault 803	P	N	Safety system test failed.
901	Fault 901	R	Y	No good lasers left.

5.5 TEST POINTS & LED ARRANGEMENT

CONTROLLER PCB:

Test Points #	Name on PCB	Function
TP1	Lamp1	LO = Fire Lamp 1 (or use as HVPS Mux Address)
TP2	Lamp2	LO = Fire Lamp 2 (or use as HVPS Mux Address)
TP3	Lamp3	LO = Fire Lamp 3 (or use as HVPS Mux Address)
TP4	Lamp4	LO = Fire Lamp 4 (or use as HVPS Mux Address)
TP5	LampModulate	Frequency to Command HVPS Lamp IGBT

TP6	LampVolts	Frequency to Command HVPS B+ Voltage on Cap Bank
TP7	CROWB	Crowbar Drive Signal to HVPS (Normally LO)
TP8	CBOK	Readback of Crowbar Signal from HVPS (Normally HI)
TP9	HVPS Analog Readback	Frequency of Selected Signal(s) Returned from HVPS (See TP16)
TP11	RemoteRX	Receive Serial Data from Remote Control Panel
TP12	D+5V	+5V Drive Signal to Laser Diode Module (ON / OFF Control)
TP13	DWIP	Digital Pot Voltage for Laser Diode (Intensity Control)
TP14	RemoteTX	Transmit Serial Data to Remote Control Panel
TP15	SFDIF	Safety Energy Detector Signal after Zero Correction Stage
TP16	HVPS Analog Readback	Signal(s) Returned from HVPS Converted to DC Level
TP17	SFZER	Safety Energy Detector Signal after Differential Amplifier Stage
TP18	GND	Ground Reference Point
TP19	GND	Ground Reference Point
TP20	GND	Ground Reference Point
TP21	MNZER	Main Energy Detector after zero correction
TP22	GTME	Greater than Min. Energy (Strobes HI with each laser pulse)
TP23	MENERG	Main Energy Signal after Peak / Hold Detector (Scope)

TP24	MNDIF	Main Energy Detector signal after Differential Amplifier stage
TP26	/4MS/	LO for 4msec during each laser pulse then HI to reset the peak detector
TP27	SENERG	Safety energy signal after Peak/Hold Detector (Scope)
TP28	SFINT	Safety Energy Detector signal after Integrator stage
TP29	/Q1/	LO for x msec during each laser pulse then HI to reset the Peak/Hold Detector
TP30	TDAC	Output of test DAC (0-10.24VDC)
TP31	-15/2	LVPS -15V monitor signal for ADC (-7.5±0.2VDC)
TP32	+15/4	LVPS +15V monitor signal for ADC (+5.0±0.1VDC)
TP33	+5V	LVPS +5V Monitor signal for ADC (+5.0±0.1VDC)
TP34	WREST	Water resistivity (VDC = 1/xMΩ)
TP35	+15V	LVPS +15V entrance to PCB (+15.0±0.4VDC)
TP36	SFVM	Safety energy signal for voltmeter (DC level, 1.0V/J)
TP37	MNINT	Main Energy Detector signal after integrator stage
TP38	MNVM	Main Energy signal for voltmeter (DC level, 1.0V/J)
TP39	-15V	LVPS -15V entrance to the PCB (-15±0.4VDC)
TP40	+24v	LVPS +24V entrance to the PCB (+24.0V±1.0VDC)
TP41	TEMP	Water Temperature (1.0VDC/10°C)

TP42	GND	Ground reference point
TP43	FSCLK	Clock for footswitch EPLD (? Hz)
TP44	INADEXP	Inadvertent Exposure
TP45	GND	Ground reference point
TP46	GND	Ground reference point
TP47	+5V	LVPS +5 VDC entrance to PCB (+5.0±0.1VDC)
TP48	FSNC1	HI when Ho or single pedal is UP (LO when DOWN)
TP49	FSNO1	LO when Ho or single pedal is up (HI when down)
TP50	BLST	HI when blastshield is installed (LO when out)
TP51	FBRIN	HI when laser fiber is connected (external switch on lens cell
TP52	FSNC2	HI when Nd pedal is UP (LO when down)
TP53	MTX	Transmit serial data to main control panel
TP54	MRX	Receive serial data from main control panel
TP55	FSNO2	LO when Nd pedal is UP (HI when down)
TP56	FBRCON	Hi when laser fiber is connected (internal contact is lens cell)
TP57	FSDN1	Hi when Ho or single pedal is down (LO when up)
TP58	/LMPDR/	Lamp Drive
TP59	LVSIN	Sine wave output of lamp volts Digital-to-Frequency Converter

TP60	FSDN2	LO when Nd pedal is down (HI when UP)
TP61	LMSIN	Sine wave output of Lamp Modulate Digital-to-Frequency Converter
TP62	CDRH	HI when Remote Interlock (BRH) circuit is closed.
TP63	GND	Ground reference point
TP64	GND	Ground reference point
TP65	GND	Ground point reference
TP66	/ADC1/	Interrupt to/from? ADC1
TP67	/ADC2/	Interrupt to/from? ADC2
TP68	1MS	1 millisecond timer (50% D.C.)
TP69	SFIRQ	Safety Error Interrupt Request
TP70	SHUTCL	Safety Shutter closed when HI
TP71	SHUTOP	Safety Shutter OPEN when HI
TP72	SATNIN	Service Attenuator IN beam path when HI
TP73	ATNIN	Low Energy Attenuator IN beam path when HI
TP75	INDEX	Servo Index Signal returned from encoder (HI = Home [#1])
TP76	CHA	Servo Channel A signal returned from encoder
TP77	CHB	Servo Channel B signal returned from encoder
TP78	SIGN	Direction command to Servo Motor Amplifier

TP79	PULSE	Speed command to Servo Motor Amplifier
TP80	/AS/	Address select signal form microprocessor
TP82	/DTACK/	Data Transfer Acknowledge Signal to microprocessor
TP83	16 MHZ	16 MHz clock for microprocessor
TP84	GND	Ground reference point
TP85	GND	Ground reference point
TP86	GND	Ground reference point
TP87	SCOP1	
TP88	SCOP2	

SERVO MOTOR PCB:

TP1	DGND	Digital ground reference point
TP2	PGND	Ground reference point

FAN SPEED CONTROLLER:

TP1	RAMP	
TP2	RAST	
TP3	FIRE	
TP4	ALLC	
TP5	DIFTEMP	
TP6	TACHU	

TP7	FGND	Ground reference point
TP8	FGND	Ground reference point

AC CONTROL PCB:

TP1	24RET	24V return
TP2	C-	

ATTENUATOR PCB:

TP1	DGND	Digital ground reference point

OPTICS BENCH PCB:

TP1	MPREA	
TP2	AGND	Analog ground reference point
TP3	AGND	Analog ground reference point
TP4	SPRER	
TP5	DGND	Digital ground reference point

5.5.1 Controller PCB LEDs

LED#	LED Board Name	Color	Description
LED1	LAMP1	GRN	When system is driving lamp #1 fiber optic cable to the HVPS. LED blinks on whenever the laser fires and during power on self-test of the HVPS.

LED2	LAMP2	GRN	When the system is driving lamp #2 fiber optic cable to the HVPS. The LED blinks whenever the laser fires and during power self-test of the HVPS.
LED3	LAMP3	GRN	When the system is driving lamp #3 fiber optic cable to the HVPS. The LED blinks on whenever the laser fires and during power on self-test of the HVPS.
LED4	LAMP4	GRN	When the system is driving lamp #4 fiber optic cable to the HVPS. The LED blinks on whenever the laser fires and during power on self test of the HVPS.
LED5	LMOD	GRN	Indicates when the system is driving the lamp modulation fiber optic cable to the HVPS. The LED is being frequency modulated and will appear as a variable intensity.
LED6	LVOLT	GRN	Indicates when the system is driving the lamp voltage control fiber optic cable to the HVPS. The LED is being frequency modulated and will appear as a continuous intensity.
LED7	CROWB	RED	Indicates when the system is sending a crowbar drive signal to the HVPS. The LED will blink during power on self test of the HVPS.
LED8	CBOK	GRN	Indicates when the HVPS is sending a crowbar OK return signal. The LED will blink for .5 sec. everytime the crowbar is fired. The LED will also blink during power on selftest of the HVPS.
LED9	VFFB	GRN	Indicates when the HVPS is sending a V-to-F feedback return signal. The LED will blink every time the crowbar is fired. The LED will also blink during power on self test of the HVPS.
LED10	REM5V	GRN	Indicates when the remote control +5V supply is on. The LED is lit when J16-8 is pulled low by way of a jumper connection to J16-7 in the remote control LEMO connector.

LED11	BLST	GRN	Indicates when the blast shield is inserted in its slot. The ground return is by way of the chassis ground straps on the laser deck.
LED12	FBRIN	GRN	Indicates when the fiber is fully inserted in the connector.
LED13	FBRCON	GRN	Indicates when the fiber is inserted in the connector.
LED14	CDRH	GRN	Indicates when the remote interlock connector is inserted in the connector. If the interlock is used in the operating room, this indicates that the remote interlock is closed.
LED15	FSNC1	GRN	Indicates that the normally closed contact in footswitch #1 is closed.
LED16	FSNO1	GRN	Indicates that the normally open contact in footswitch #2 is closed.
LED17	FSNC2	GRN	Indicates that the normally closed contact is footswitch #1 is closed.
LED18	FSNO2	GRN	Indicates that the normally open contact in footswitch #2 is closed.
LED19	FSER2 / FSDN2	RED / GRN	If the LED is illuminating in the red, then footswitch #1 is in an error state, both contacts low, high, etc. If the LED is illuminating in the green, then footswitch #1 is fully depressed and debounced.
LED20	FSER2 / FSDN2	RED / GRN	If the LED is red, then footswitch #2 is in an error state, both contacts are low or high. If the LED is green, then footswitch #2 is fully depressed and debounced.
LED21	NFIRE	RED	Indicates that the 'No fire" bit from the DIO is active and the HVPS is disabled.
LED22	SHUTCL / SHUTOP	GRN / RED	If the LED is green, then the safety shutter is closed. If the LED is red, then the safety shutter is open.

LED23	INAD	RED	Indicates that the inadvertent exposure monitor was tripped. This situation occurs when neither footswitch is depressed, the safety shutter was fully open and the minimum light energy detector was active.
LED24	ATNIN	GRN	Indicates that the main 40% attenuator is in place.
LED25	REMTX / REMRX	GRN / RED	If the LED is green, this indicates that there is communication on the remote control transmit line. If the LED is red, then there is communication on the remote control receive line.
LED26	SATNIN	GRN	Indicates that the service attenuator is in place.
LED27	MTX / MRX	GRN / RED	If the LED is green, this indicates communication on the DEECNO transmit line. If the LED is red, this indicates that there is communication on the DEECNO receive line.
LED28 (GREEN)	CH_A / CH_B	RED / GRN	(RED) Indicator of the Channel A servo motor encoder bit from the laser servo motor. Indicator of the Channel B servo motor encoder bit from the laser servo motor.
LED29	PULSE / SIGN	GRN / RED	(GREEN) It is an indicator of the PWM output of the HCTL110 servo motor controller. This is the pulse width modulate control bit from the servo controller. (RED) It is the indicator of the sign output of the HCTL110 servo motor controller. This is the direction control bit from the servo controller.
LED30	INDEX	GRN	It is an indicator of the index or home position from the servo motor encoder.
LED31	AS/ /AS/	GRN / RED	(GREEN) This indicates when the address strobe from the microprocessor is high. Both LEDs must be flashing without being illuminated continuously. (RED) Indicates when the address strobe from the microprocessor is low. Both LEDs must be flashing without being illuminated continuously.

5.6 REMOVE/REPLACE PROCEDURE

This section provide procedures in the removing and replacement of major components in the VersaPulse PowerSuite laser. Prior to removing / replacing any components in the system, the covers must be opened or removed (i.e., side covers). Refer to Section 5.2 for the removal of any of the covers. *Be sure all ESD protocols are observed when removing/replacing any electronic component. Also, when removing/replacing any optical components, be sure it is free of any contaminants.*

5.6.1 Flashlamp Replacement

1. Turn the system off and disconnect the AC power cord from the AC power source.

2. Open the front door, remove the top and optics bench cover from the laser.

3. Drain the coolant. (Refer to Subtopic 5.6.4).

4. Measure B+ capacitor charge.

CAUTION: Do not touch the flashlamp wires or laser pod terminals unless the B+ charge is at 0 VDC. This typically takes 10 minutes after disconnecting the power cord from the AC power source.

5. Disconnect the flashlamp wires from the terminal block.

Support the wire at the flashlamp end and carefully straighten out the red wire at the opposite end. (If the wire is not supported at the flashlamp, the flashlamp may break.

6. Remove the flashlamp(s).

a. Remove the cavity assembly, if not already removed.

Be careful to note the location of the two cavity assembly O-rings between the cavity and the manifold.

b. Remove the insulated end blocks surrounding the flashlamp ends. This releases the pressure from the O-rings.

c. Put on latex gloves and clean the red wire of the old flashlamp with methanol and lens tissue.

This step MUST BE PERFORMED to prevent contamination from being dragged and deposited inside the cavity flow tube.

d. Carefully slide the flashlamp out of the cavity assembly in the direction of the black wire.

Take caution to locate the O-rings. Note the position of the O-ring on the black end of the old flashlamp. Locate the loose O-ring and place it on the new flashlamp at approximately the same location as the old flashlamp. Remove the other O-ring from the old flashlamp.

7. Install the new flashlamp.

a. Carefully straighten the red wire on the new flashlamp and clean the entire flashlamp with methanol and lens tissue. Be sure to wipe the flashlamp several times and each time using a new lens tissue paper.

b. Carefully insert the red wire into the cavity assembly until the flashlamp is visually centered within the cavity.

NOTE: The brick are bi-directional. Install the remaining O-ring on the flashlamp.

c. Install the insulated end blocks keeping the flashlamp visually centered within the cavity assembly.

d. Replace the cavity assembly on the laser pod and attach the flashlamp wires to the terminal block.

8. Add coolant and check for leaks, specifically in the cavity assembly area.

9. Perform the "Resonator" and "Fiber" alignment procedures, then check the flashlamp calibration values.

10. Reinstall all the covers and front door.

5.6.2 Controller PCB Replacement

1. Turn the system off and disconnect the AC power source.

2. Open the front cover. (Refer to Fig. 5.1).

3. Remove all electrical and fiber optic connections from the Controller PCB.

4. **Remove the five nuts securing the Controller PCB to the standoffs and remove the Controller PCB.**

5. **Install the new Controller PCB and secure it in place using the five nuts that was just removed.**

   CAUTION: Be sure ESD protocols are observed when handling the new Controller PCB, otherwise severe damage to the Controller PCB may occur.

6. **Reconnect all the electrical and fiber optic connections.**

7. **Verify the three switches (i.e., service, auto cal and service attenuator) on the Controller PCB are in the proper positions.**

8. **Turn the laser on and perform the calibration procedures in Section 3 of the Service Manual.**

9. **Verify the laser is operating properly.**

10. **Perform the Operation and Safety Procedure in Section 3.**

5.6.3 Water Filter Replacement

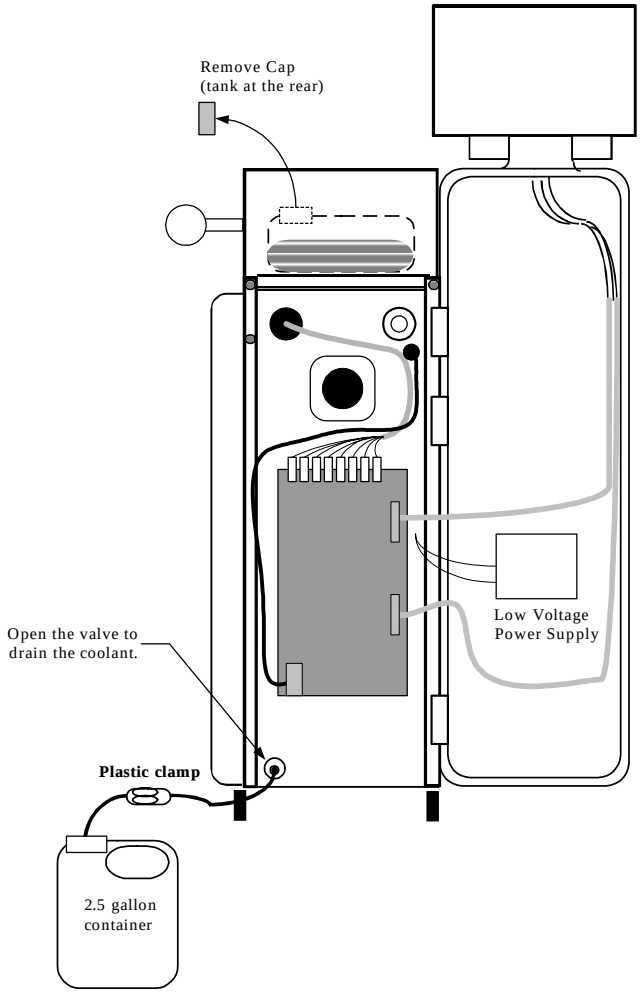
1. Open the front door and remove the top cover, then remove the left side panel. Refer to Topic 5.2.

2. Drain the coolant.

a. Remove the “Remote Interlock” or BRH plug from the rear of the laser console and remove the yellow cap on the fill reservoir.

b. Place a bucket under the drain outlet and open the valve. The flow will eventually decrease and become intermittent.

NOTE: If the coolant is to be changed, the drained coolant requires no special handling - it can be poured down the nearest drain.



c. Unscrew the clear plastic water filter canister, remove the filter and any remaining water inside the canister, and install a new water filter.

d. Close the drain valve.

3. Refill the cooling system. Refer to Section 2 Subtopic 2.1.4.

Upon turning on the system and after the cooling system is properly filled, verify there are no fault codes pertaining to the cooling system appearing on the display.

5.7 TROUBLESHOOTING

The following is a general check list and troubleshooting guide for the VersaPulse **PowerSuite** trained service engineer. Procedures referenced in this section for adjustments, alignments, calibrations and checks are provided in Section 3.

If any of the following components have been adjusted or replaced, perform the related adjustments, alignments, calibrations, and checks.

OPTICS & OPTICS RELATED COMPONENTS

1. Lamp, Rod, HR, OC, or Cavity:

- Cavity Alignment
- Fiber Alignment
- Check Autocalibration Values
- Perform Operational and Safety Checks

2. First Relay, Plano Relay:

- Fiber Alignment
- Check Autocalibration Values
- Perform Operational and Safety Checks

3. Servo Mirror, Servo Motor (Ho & Ho/Nd:YAG Only):

- Orient Servo Mirror on Motor Shaft
- Fiber Alignment
- Check Autocalibration Values
- Perform Operational and Safety Checks

4. First or Second 45• Folding Mirror:

- 45• Folding Mirror Alignment
- Fiber Alignment
- Check Autocalibration Values
- Perform Operational and Safety Checks

5. Lens Cell Assembly:

- External Fiber Switch Adjustment
- Fiber Alignment
- Check Autocalibration Values
- Perform Operational and Safety Checks

6. Blastshield Optic:

- Check Autocalibration Values
- Perform Operational and Safety Checks

7. Aiming Diode Laser, Aim Beam Mirror, Beam Combiner Optic:

- Aiming Laser Alignment
- Check Autocalibration Values
- Perform Operational and Safety Checks

PCBs

Optics Bench PCB:

- Pyro Imaging Mirror Alignment
- Main and Safety Energy Pre-Amp Calibration
- CPU Energy Monitor Calibration
- Check Autocalibration Values
- Perform Operational and Safety Checks

Controller PCB:

- Speaker Volume Adjustment
- CPU Energy Monitor Calibration
- Check Autocalibration Values
- Perform Operational and Safety Checks

Fan Speed Controller PCB:

- Fan Idle Speed Adjustment
- Perform Operational and Safety Checks

POWER SUPPLY

HVPS:

- Check Autocalibration
- Perform Operational and Safety Checks

LVPS:

- Output Voltage Adjustment
- Perform Operational and Safety Checks

OTHER COMPONENTS

Fan Motor / Impeller, Pump Motor, Pump Head, Waterflow Switch, Water Temp Sensors, Filters (DI, particle, air) and General Plumbing:

- Fan Idle Speed Adjustment
- Perform Operational and Safety Checks

Display:

- Load Logo
- Check Autocalibration Values
- Perform Operational and Safety Checks

The following are common faults which may occur during the operation of the laser.

TEMPERATURE

1. *The overheating fault is displayed on the LCD screen.*

a. Verify that the coolant is at its proper level. (The upper water reservoir should be between one-half full.

b. Perform the Fan Speed Controller Adjustment in Section 3.3.2.

c. Verify that the water particle filter is clean. If the filter is dirty or discolored (brown), drain the laser and replace the particle filter and DI cartridge.

d. Check the cleanliness of the air filter on the bottom of the laser. A dirty air filter will restrict air flow. (This filter should be vacuumed periodically.

e. Verify that there is adequate space at the bottom of the system when it is in use. (There may be other carts or equipment in the operating theater next to the VersaPulse PowerSuite reducing the air flow to the laser.

f. Verify that the ambient temperature of the operating environment is below 22•C.

e. Verify that water hoses are not bent, kinked, or otherwise damaged.

f. Check lamp calibration values. (Higher lamp energies or cal points means more energy must be dumped into the lamps creating more heat.)

If all of the above items are checked and found to be normal yet, the laser still overheats, it may be possible that the water pump head is worn and not moving the water quickly enough or there may be some flow restriction. Or everything may be normal but the system just need to be left on so the laser would cool down. If the laser overheats, *do not turn it off!* Let it run and it will cool down.

BLASTSHIELD

The following section will address the subject of "blown blastshields" and the causes for this problem.

Laser energy is focused at the center of the proximal endface of the fiber. Due to the causes listed in the following topics, the fiber endface will tend to absorb or scatter more laser energy than it transmits. During laser operation, the temperature of the fiber endface will increase. When the temperature exceeds the energy handling capacity of the fiber, the heat generates a violent reaction within the fiber and fiber endface "explodes".

This small scale "explosion" ejects sparks, hot gases, and debris away from the fiber endface. While most of the debris is sent out of the lens cell vents, some of the debris is directed toward the blastshield. The blastshield sacrifices itself in the explosion, and in doing so, protects the fiber focus lens from damage. The blastshield is now "blown", and each additional laser pulse will create another explosion. The fiber *and* blastshield need to be replaced before any further laser operation takes place.

It is recommended that all customers carry additional fiber delivery devices and a spare blastshield FRU.

1. *The system is blowing blastshields.*

a. Visually inspect Blastshield Optic for contamination or signs of damage. Replace if necessary.

b. Verify fiber alignment. (See Section 3 for details)

c. Interview the customer to determine system usage to calculate the failure rate and to collect other important information. Ask the following questions:

- What type of fiber delivery device was in use at the time?
- Who is the manufacturer?
- How many times was this device used / sterilized?
- How much energy was put into the device?
- Could the failure be handling or procedure related?

If the blastshield glass was known to be new or clean at the time, the optical alignment checks out to be normal, the fiber was new and was being properly used, yet the system continues to consume blastshields at a high rate, check for contamination on the fiber focus lens.

To check the fiber focus lens, remove the fiber focus assembly from the laser, then remove the lens cell by first removing the beam combiner. If the lens is contaminated, clean or replace as necessary. Make a final alignment check by inspecting the test fiber burn.

FIBER ENDFACE

1. *The fiber endface explodes:*

- The fiber may have been previously used or autoclaved (high temperature sterilized) and / or its lifetime or wear rating has been exceeded. This is probably most common with VersaLinks and SlimLine Bare Fibers that are used more than once.

- The fiber (SMA end) may be damaged or contaminated which is most commonly associated with improper handling of the fiber or firing through a blown blastshield.

- Contamination on blastshield may be scattering or unfocusing laser energy at the fiber endface. Typically, the causes are a fingerprint on the blastshield glass, the glass has been previously cleaned or not thoroughly cleaned, or the glass has suffered an earlier blast.

- The laser optical alignment (on one or more channels) is not centered and / or peaked as measured with, respectively, the 10mm Test Aperture and the Transimpedance Detector.

- Contamination of fiber focus lens may be scattering or unfocusing laser energy at the fiber endface. This is usually caused by multiple explosions where a small percentage of the debris may be making its way to the fiber focus lens.

It is necessary to perform the Operational and Safety Checks found at the end of Section 3 after the servicing and repair of the laser.

6.0 SELECTED PARTS

The Bill of Materials for the VersaPulse® PowerSuite™ laser is maintained under document control at Lumenis in Santa Clara, California, and is subject to change. The following list is provided for convenience - always confirm the P/N for a given part through Technical Support before ordering.

SPECIAL TOOLS

Glasses, safety	0638-429-01
Goggles, safety	0638-430-01
Fiber, test, alignment	0621-675-01
Fiber, test, calibration	0623-973-01
Paper, burn	3207-0091
Marker, red	Call Technical Support
Detector, transimpedance	0614-868-51
	Fiber, stub, 200µm0615-103-51
Target, 1/2" cross-hair	0621-131-51
Fixture, alignment, servo	0622-782-51
Microscope, 100x	0623-171-51
Aperture, 10mm, cast	0622-919-51
Rod O-ring Install Tool	0629-554-01

USER REPLACEABLE SUB-ASSEMBLIES

Footswitch Ass'y, single	0637-458-01
Footswitch Ass'y, dual	0638-709-01
Remote Control Panel	0626-434-01
Debris Shield, FRU	0624-015-01
Optics, Blastshield	0623-502-01
Snap Ring	2504-0012
Wave Washer	2508-0011
BRH Interlock Plug, FRU	0625-962-01

LUMENIS™
Enhancing Life. Advancing Technology.

CONTROL SYSTEM PRINTED CIRCUIT BOARDS

CPU PCB w / EEPROM, 100W	0638-741-01
CPU PCB w / EEPROM, 80W	0638-741-02
CPU PCB w / EEPROM, 60W	0638-741-03
CPU PCB w / EEPROM, 45W	0638-741-04
CPU PCB w / EEPROM, 30W	0638-741-05
CPU PCB w / EEPROM, 80W (JAP)	0638-741-06
CPU PCB w / EEPROM, 30W (JAP)	0638-741-07
CPU PCB w / EEPROM, 80 / 100W	0638-741-08
CPU PCB w / EEPROM, 60 / 100W	0638-741-09
CPU PCB w / EEPROM, 60 / 100W (JAP)	0638-741-10
CPU PCB w / EEPROM, 20 / 60W	0638-741-11
Display panel, FRU	0636-016-01
Optics Bench PCB	0636-039-01
Attenuator PCB	0636-043-01
Servo Amp PCB	0636-041-01
AC Control PCB FRU	0638-733-01
Fan Speed Controller PCB	0636-049-01
Start Indicator PCB (on Pod)	0626-987-01
Tach Speed Sensor PCB	0632-444-01

HIGH VOLTAGE POWER SUPPLY

HVPS, Ho, 2 channel	0638-632-01
HVPS, Ho, 3 channel	0638-633-01
HVPS, Ho, 4 channel	0638-080-01
HVPS, Dual λ	0638-634-01
Power Supply Controller PCB	0626-695-01
Simmer / Start PCB	0626-697-01
DC Injection PCB	0626-705-01
IGBT Driver PCB	0626-701-01
Crowbar Driver PCB	
Bridge Rectifier	4802-0728
Fuse, B+	5110-0302
Fuse, 1A	5110-0251
Fuse, 100mA	5110-0326
Fuse, 250mA	5110-0248
Fuse, 50mA	5110-0263

CHASSIS & SKINS

Castor, front	1407-0163
Wheel, rear	1407-0164
Cover Ass'y, Top	0635-023-01

Cover, side (key)	0637-148-01
Cover, side (blastshield)	0621-506-01
Handle, top Cover	0619-410-01
Handle, front cover	0619-411-01
Front Door ass'y (method)	0637-366-01
Cover, blastshield	0621-132-01
Latch, front door (kit)	1406-0146
Castor, front	1407-0163
Wheel, rear	1407-0164
Bumper, front door	0619-668-01
Bumper, side panel	0621-057-01
Hinge, door	1406-0147
Latch pins, Frame	1406-0127
Nose Bezel w / all hardware	0638-734-01
Nose Bezel w / all hardware (JAP)	0639-004-01
Side Panel, Right	0638-735-01
Side Panel, Left	0638-736-01
Slide, HVPS	1403-0041

CHASSIS ELECTRICAL/MAJOR SUB-ASSEMBLIES

Power cord, 3 x 10AWG (25')	6005-0166 (order by foot)
Circuit breaker, 32A / 250V	5108-0147
Contactor, Main	4501-0536
Contactor, Aux	4501-0537
Line filter	0638-295-01
Keyswitch FRU	0638-728-01
Key	5107-0190
Emergency Stop Switch	0631-941-01
Cap, Red (for E-Stop SW)	5102-0123
Filter, Cap Board	0638-054-01
Transformer, Isolation, kkVA	0637-894-01
Surge Protector (on AC Control PCB)	5109-0014
Fuse, T4A, 250V	5110-0254
Fuse, T2A, 250V	
Fuse, T1A, 250V	5110-0251
Fuse, T1 / 2A, 250V	
Low Voltage Power Supply	4001-0253
Fan Capacitor	2601-0145
Switch, External, attach fiber	5102-0128
Solenoid, Rotary, CW, Safety Shutter, Svc Attenuator	0638-764-01
Solenoid, Rotary, CCW, LE Attenuator	0638-765-01
Servo Motor w / Connector	0638-737-01
Laser Diode Module	0638-491-01
Receptacle, footswitch	2805-0296
Plug, BRH	0625-962-01
Plug, footswitch (LEMO w / pins)	2104-1118
Rear Panel Connector Ass'y	0638-739-01
Cable, Graphics Assembly	0638-766-01

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CABLE SETS/HARNESSES

Optical Fiber Set (CPU-HVPS)	0632-527-01
Line Filter to Circuit Breaker	0638-062-01
CPU cable set	0637-264-01
LVPS to CPU	0633-727-01
AC (interlock) harness	0637-263-01
Pump motor cable	0637-475-01
HVPS mains cable	0637-265-01
Blastshield Switch Ass'y	0638-740-01
Temp Sense, Air, Fan	0637-462-01
Temp Sense, Water, Fan	0637-463-01
Temp Sense, Water, CPU	0637-476-01

COOLING SYSTEM

Fan / Motor Ass'y FRU	0638-731-01
DI Cartridge	0638-763-01
DI Water	0622-440-01
Particle Filter ass'y FRU	0638-729-01
Particle Filter, 0.2µm	2603-0147
Flowswitch w / Fitting	0638-730-01
Filter, Air	0622-418-01
Pump Head / Manifold FRU	0638-726-01
Pump Motor	3501-0143
Pump Head Clamp, V-band	3501-0142
Motor Base plate	0619-940-01
Heat Exchanger, Water-to-Air, Alum	0635-684-01
Heat Exchanger, Water-to-Water FRU	0638-725-01
Hose, Braided, 0.5" ID	2521-0032
Hose, Braided, 0.25" ID	2521-0216
Tube, Clear, 0.5" ID	2521-0217
Tube, Clear, 0.25" ID	2521-0167
Tubing, Tygon	2521-0036
Hose Barb, Beam Dump, Straight	2518-0629
Hose Barb, Beam Dump, 90•	2518-0346
Quick Connect, Male, Straight	2519-0213
Quick Connect, Male, Right Angle	2519-0207
Quick Connect, female (on DI Cart.)	2519-0209
Temp Sensor ass'y., air FRU	0638-732-01
Temp Sensor ass'y, water	0637-476-01
Conductivity Sensor	0635-721-01
Manifold, Drain	
Valve, Drain	2206-0112
Valve, check (on lower tank)	2206-0117
Foam Tape	3207-0037

OPTICS, COMMON

Flashlamp	0626-879-01
Cavity ass'y., rodless	0637-989-01
Wedge	0636-799-01
Spacer (for wedge optic)	0636-800-01
Mirror, 45• folding	0623-497-01
Mirror, servo	0625-352-01
Mirror, pyro imaging	0626-994-01
Attenuator, low energy	0623-500-02
Attenuator, service	0623-500-01
Shutter	0623-500-01
Blastshield, FRU	0624-015-01
Blastshield, Optic	0623-502-01
Beam Combiner ass'y. (method)	0637-349-01
Diode Mirror ass'y. (method)	0637-705-01
Screw, adjustment, optic, long	0637-720-01
Screw, adjustment, optic, short	0637-352-01
Nut, locking (for adjustment screws)	0629-721-01
Retainer, mirror	0619-296-01
Mirror, first relay	0623-494-01
Mirror, Servo, Motor	0625-352-01

OPTICS, HOLMIUM

Lens Cell, Ho FRU	0638-911-01
Cavity, Ho, FRU	0639-855-01
OC, Ho	0637-153-01
HR, Ho	0626-872-01
Plano Relay, Ho	0619-385-01

OPTICS, NEODYMIUM

Lens Cell, Dual λ	0638-886-01
Cavity, Nd, FRU	0638-883-01
OC, Nd	0623-493-01
HR, Nd	0626-875-01
Plano relay, Nd	0623-495-01

7.0 FIELD SERVICE BULLETINS

7.0 FIELD SERVICE BULLETINS

The information in this Service Manual is subject to change without notice. As required, Lumenis Service Department Technical Support releases Field Service Bulletins (FSB's) to update its Field Service Engineers on technical issues concerning this product. At its release, the FSB's become part of this Service Manual.

Place the FSB's for this Service Manual, and the FSB Index distributed with each FSB, behind this page.

VERSAPULSE POWERSUITE FIELD SERVICE BULLETIN INDEX - 2 JULY 2001

NUMBER	DATE	TITLE
	2 JULY 2001	CODING INSTRUCTIONS
1	22 MAY 2000	REV. H HIGH VOLTAGE POWER SUPPLY CONTROLLER PCB P / N 0626-695-01
2	2 JULY 2001	SOFTWARE CHANGES & NEXT CALL RETROFIT (9800)

CODING INSTRUCTIONS: VERSAPULSE PRODUCT LINE
2 JULY 2001

The following are instructions for coding service actions on the SYSTEM CERTIFICATION REPORT, including the VersaPulse Product Lines Detail Identifier List (begins on next page). Refer to the Service Department Policies & Procedure Manual for additional information on the Service Reporting System and System Certification Report.

The Maintenance Information Box on the form includes multiple fields for service action codes (SAC's). Each entered code specifies, for computer input, the service action completed during the call. If no service actions are completed, no SAC's are necessary. Note that only completed actions should be reported.

The text area of the Maintenance Information Section of the form is used to provide additional detail on the service actions taken, as determined appropriate by the Servicing Engineer.

The first two characters of the sac form the Product Category Identifier. There are six Product Category Identifiers (PC, VP, CO, OP, NV and YG). The Product Category Identifier used for the System Certification Report is "VP".

The next four characters of the SAC form the Detail Identifier. Select the appropriate four character identifier from the list beginning on the next page.

- Install, De-install and PM, use identifiers from the "0000" category.

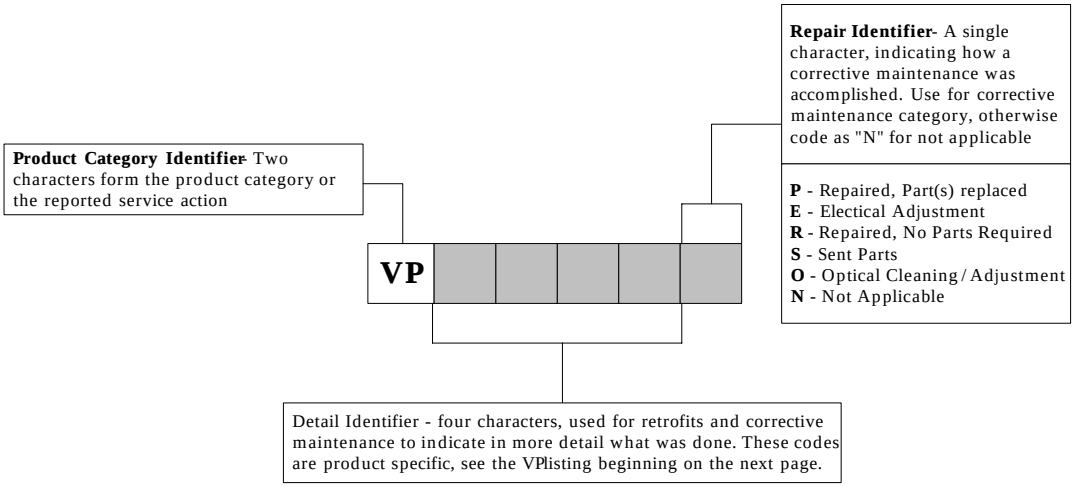
- For coding corrective maintenance actions, select the appropriate identifier from the categories 1000 through 8000. When coding failures, identify the source of the failure, but not those adjustments or alignments made necessary by the repair, then select the appropriate identifier under the proper category. For example, if a tube / exciter fails and is replaced, do not code all the additional adjustments and alignments required as a result of the new tube / exciter installation, code only the tube / exciter failure (6010).

- For Retrofits, the identifier under "9000" category indicates a particular retrofit.

- When a specific identifier does not identify the failure, use the more general identifier, such as "3000" for a cooling system failure that is not more specifically identified within the "3000" series of identifiers.

VP CODING INSTRUCTIONS: CONT. 2 JULY 2001

The last character of the SAC indicates the method of repair, in cases of corrective maintenance. For installs, de-installs, retrofits and preventive maintenance calls, an "N" is used to indicate "not applicable".


Repair Identifier - A single character, indicating how a corrective maintenance was accomplished. Use for corrective maintenance category, otherwise code as "N" for not applicable
P - Repaired, Part(s) replaced
E - Electical Adjustment
R - Repaired, No Parts Required
S - Sent Parts
O - Optical Cleaning / Adjustment
N - Not Applicable
Product Category Identifier - Two characters form the product category or the reported service action
VP
Detail Identifier - four characters, used for retrofits and corrective maintenance to indicate in more detail what was done. These codes are product specific, see the VPlisting beginning on the next page.

The System Performance Data Box of the form is used to provide critical performance data after the service has been completed. The following performance data for the VersaPulse PowerSuite system must be written in the System Performance Data Box:

- Lamp Calibration Values

Table 1:

	#1	#2	#3	#4
Hi				
Lo				

- Water Conductivity (µS)
- Mains Voltage (VAC) TAP: 200 220 240 (circle one)
- Software Revision

VP CODING INSTRUCTIONS: CONT. 2 JULY 2001

VERSAPULSE CODES

0000 - GENERAL
0001 Install Laser
0002 De-Install Laser
0003 Preventive Maintenance
0004 Optical Alignment
0005 Calibration
0006 See Maintenance Text

1000 - FRAME, HARDWARE, COVERS
1100 Top Cover
1200 Side Cover
1300 Front Cover
1400 Rear Cover
1500 Display Panel
1600 Wheels / Castors
1700 Handles
1800 Door Latch Parts
1900 Labels

2000 - TURN ON / OFF, AC / DC POWER DIST.
2010 Power Cable / Plug
2020 Circuit Breaker / Fuse
2030 Line Filter
2040 Softstart Circuitry
2100 Contactor
2110 Key / Stop Switch
2120 Interlock Switch
2130 Relay
2150 Flowwheel PCB
2200 Terminal Block
2210 Fuse Block
2230 Mains Transformer
2240 LVPS

3000 - COOLING SYSTEM
3010 Pump / Motor / Fuse
3020 Flowswitch
3030 Heat Exchanger
3040 Fan Speed / Sensor / Fuse
3050 Water Tank
3060 Fan / Motor / Fuse
3070 Air Filter
3300 Flow Wheel
3310 Muffin Fan
3330 Air Pump
3340 Air Dryer
3350 Chiller
3900 Water Temp Sensor
3910 Hose / Fitting / Clamp
3920 Pressure Gauge
3930 Valve
3940 Bladder
3950 Manifold
3960 Coolant
3970 DI Cartridge
3980 Particle Filter / Holder
3990 Conductivity Sensor

4000 - CONTROL ELECTRONICS
4010 Control PCB
4040 Shutter PCB
4050 Single Solenoid PCB
4060 Dual Solenoid PCB
4070 Servo Amp PCB
4080 Servo Motor
4090 Display Electronics
4100 Pyro Board / 2.1
4200 Optics Interconnect PCB
4210 Handpiece Interface PCB
4220 Rear Panel I / O PCB
4230 Galvo Driver PCB
4240 Output Selector PCB
4250 ICS PCB
4260 Beam Dump PCB
4270 VPW Photometer PCB
4280 QS Photometer PCB
4290 QS Driver PCB
4300 Arm / Fiber Selector
4430 Remote Control Panel
4930 Stepper / Galvo / Solenoid
4960 Software
4970 BRH / Interlock Plug
4980 Footswitch
4990 Connector / Cable

5000 - LASER TUBE CONTROL & POWER SUPPLY
5010 HVPS, Coherent
5020 HVPS, CPI
5030 Select PFN
5040 Simmer Power Supply
5120 PS Controller Board
5130 Simmer / Start Board
5140 IGBT Driver Board
5150 Softstart Contactor
5160 IGBT
5170 HVPS Fuse
5300 2.1 HVPS
5320 2.1 PFN
5330 Trigger PCB
5340 Capacitor PCB
5970 FET / SCR
5980 Storage Capacitor
5990 Fiber Optic Cable

6000 - CAVITY & OPTICAL COMPONENTS
6010 Flashlamp
6020 Lamp Terminal

VP CODING INSTRUCTIONS: CONT. 2 JULY 2001

6030 Cavity or Brick
6040 O-Ring
6050 Flow Tube/Shotgun
6060 HR/OC, Ho
6080 Rod, Ho
6090 HR/OC, Nd
6110 Rod, Nd
6120 Rod, QS Nd
6130 HR/OC, Alex
6140 Rod, Alex
6150 HR/OC, Er
6160 Rod, Er
6170 Q-Switch
6180 Servo Mirror
6190 Telescope
6870 Beam Combiner
6880 Beam Splitter Optic
6890 Prism
6900 Blastshield
6910 Lens Cell
6920 Fiber Aiming Laser
6930 Arm Aiming Laser
6940 Relay Mirror
6950 Pick-Off Optic
6960 Turning Mirror
6970 Polarizer Optic
6980 Quater-wave Plate
6990 Optical Mount

7000 - ARM
7010 Arm
7020 Lock Mechanism
7030 Tower/Collar Ass'y.
7040 Arm Hardware
7050 Arm Alignment
7060 Arm Output Window

8000 - DELIVERY SYSTEMS
8100 Fiber Cable Ass'y.
8110 Fiber Handpiece
8120 Chilled Tip Ass'y.
8130 Chiller
8200 Arm Handpiece
8210 Arm Handpiece Cable
8220 Arm Handpiece Window
8230 Handpiece Tube

9000 - RETROFIT

(2.1)
9010 AN - Coolant conductivity (3Z51) 2.1 & XE<310075 FSB#8
9020 AN - Lost Cal. (3Z52) 2.1 & XE<310075 FSB#8
9030 AN - Attenuator (3Z53) 2.1 & XE<310075 FSB#8
9040 AN - Software (3Z54) FSB#8
9050 AA - Fiber Focus Ass'y. (3Z55) 2.1 before 3/92 FSB#9
9060 AN - ESD Protect (3Z57) 2.1 before 5/92 FSB#12
9070 AU - 2000 to 2000SDE (3Z58) 2.1 2000's FSB#13
9080 AN - Chiller Float Switch (3Z60) 2.1 3000 & 4000 FSB#19
9090 AN - Chiller Float Switch (3Z60) 2.1 3000 & 4000 FSB#19
9100 AN - 3 Joule Software (3Z61) 2.1 2000's w/new CPU & 3000's, FSB#20
9110 SN - 2.1/3000 Software, 2.1 3000's FSB#14

(Select)
9200 AN - Fan/PFN/F5 (4Z01) <0200 FSB#2R1 & 6
9210 AN - Simmer P/S Resistor (4Z02) <0200 FSB#10
9220 AA - Case Saver Software (4Z02) <0200 FSB#11
9230 AU - Select Max Power (4Z04) Holmium only FSB#12
9240 AU -Mobile Wheel (4Z05) Select>0045 FSB#7
9250 AA - Select Lens Cell (4Z06 & 07) before 1/94 FSB#14, 15
9260 AU - Dual F/S (4Z08) Dual only FSB#16
9270 AU - Remote Control (4Z09) Select FSB#17
9280 AN - Erbium Rev. C Software Rework

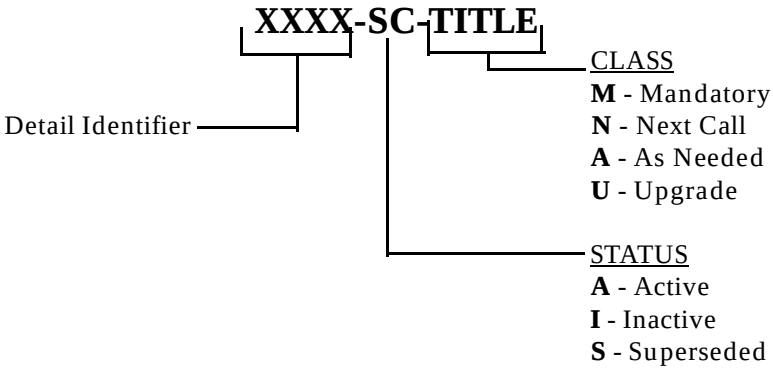
(Select II)
9290 AN - Software/Controller update (Select II Dual & Ho: only with s/n's ending in range 1000 to 1200 FSB#1
9291 AN - System Changes and Next Call Retrofit FSB#2
9292 AN - Pyro Detector, Servo information and Next Call Retrofit FSB#4

(UltraFine/Erbium)
9300 AN - System Changes and Next Call Retrofit FSB#1
9310 AN - System Changes and Next Call Retrofit FSB#2
9311 AN - System Changes and Next Call Retrofit FSB#4

(VPW & C)
9700 AN - VPW System Changes & Next Call Retrofit
9701 AM - HELP-G Upgrade FSB#2
9702 AA - System Changes and Next Call Retrofit FSB#3

(VP PowerSuite)
9800 AN - Software Change & Next Call Retrofit (FSB#2)

VP CODING INSTRUCTIONS: CONT. 2 JULY 2001



Retrofit information includes the Detail Identifier, followed by single letter codes indicating the class and status of the retrofit, as defined in the diagram above. Note that the class and status are not part of the Service Action Code used to report the completion of the retrofit (all VP retrofits are coded as “VP9xxxN”, where “9xxx” is the Detail Identifier as assigned above).

VERSAPULSE POWERSUITE FSB #1: REV. H HIGH VOLTAGE POWER SUPPLY CONTROLLER PCB (P/N 0626-695-01) 22 MAY 2000

INTRODUCTION

This Field Service Bulletin provides information on the Revision "H" High Voltage Power Supply (HVPS) Controller PCB for the VersaPulse® PowerSuite™ laser.

0626-695-01 REVISION "H" CONTROLLER PCB

Revision "H" HVPS Controller PCBs (P / N 0626-695-01) are now being shipped in production systems and is also available as a replacement part. The next revision of the VersaPulse PowerSuite service manual will include an updated schematic of the revision "H" High Voltage Power Supply Controller PCB.

The following information for the revision "H" High Voltage Power Supply Controller PCB is of particular interest to the service organization.

In revisions A - G of the HVPS Controller PCB, SW6: 1-4 disables the HighVoltage Power Supply by enabling the /SHUTDOWN/ signal from the Power Factor Controller (this was to allow a test of the "SHUTDOWN" circuit). Under ECO# 68444, the function of SW6 was changed and became part of the overtemp circuit. The modification included cutting a trace between SW6:1 to U47 (shutdown circuit), and connecting a 237kΩ resistor (R226) in series between SW6:1 to U14-3 (overtemp circuit). In this new configuration, if SW6:1-4 is in the open (default) position, the over temperature fault will occur if the coldplate temperature reaches 90° C (refer to the circuit diagrams below). If SW6 is in the closed position, (which it should never be in a VersaPulse Power Suite), erroneous faults may occur, due to the overtemperature parameter being set too low (75° C).

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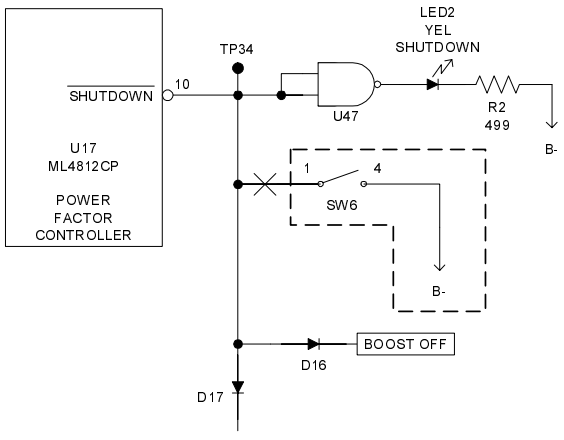
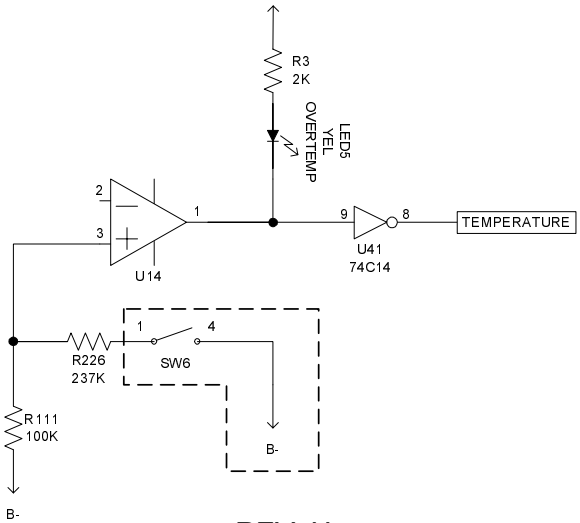
POWER SUPPLY CONTROLLER BOARD
0626-695-01
[used on VersaPulse PowerSuite]

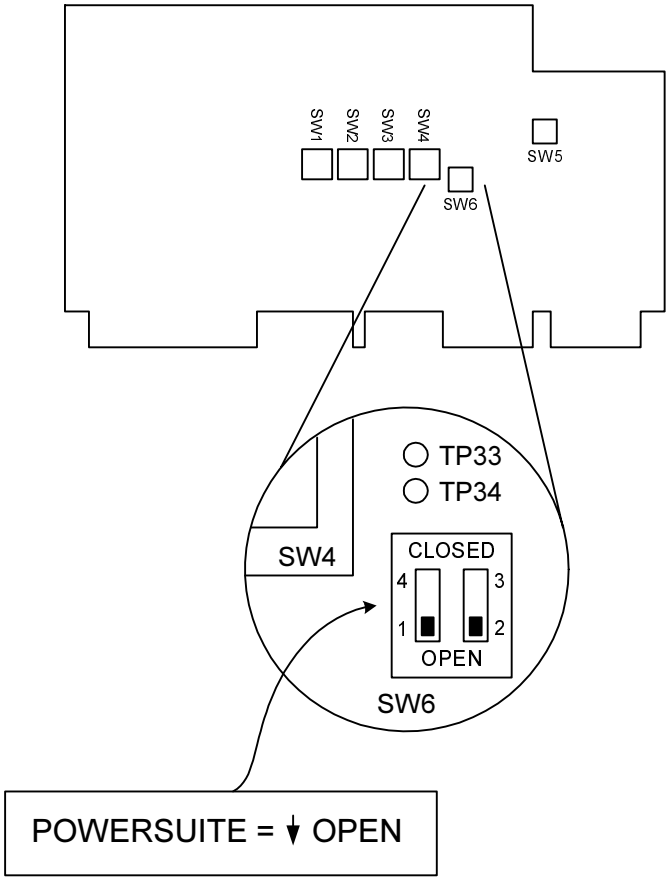


REV. A-G



REV. H

VERSAPULSE POWERSUITE FSB # 1: CONT.



Note that there may be systems in the field that may not have a revision "H" HVPS Controller PCB in the High Voltage Power Supply. So it is important to always verify the revision level of the HVPS Controller PCB and insure SW6:1-4 is in the proper position, otherwise the following conditions will occur (refer to the chart below). Keep in mind that all High Voltage Power Supplies shipping from Coherent will already have the revision "H" Controller PCB.

Rev. Level of the PCB	SW6 in the open position (Correct)	SW6 in the closed position (Incorrect)
A - G	Disables the shutdown test function circuit for the Power Factor Controller and allows the HVPS to operate	Enables the /SHUTDOWN/ and disables the HVPS.
H	Sets the appropriate over temperature fault limit at 90° C.	Sets the over temperature fault limit at 75° C, which is incorrect.

VERSAPULSE POWERSUITE FSB #2: SOFTWARE CHANGES & NEXT CALL RETROFIT (9800) 2 JULY 2001

INTRODUCTION

This Field Service Bulletin provides information on the following per ECO# 69435:

- Introduces revision "D" release of the VersaPulse® PowerSuite™ software, which corrects the following bugs:

  * Removes the word TREATMENT from the screen which was displayed after the system had dropped to STANDBY as a result of a system fault.

  * Adds a 2 J @10 Hz Holmium operating parameter to the 20/60W model.

  * Disables the "Auto Shut-off" feature in the burn-in software in all field units manufactured before February 2001.

- Orders an inspection of the rear panel cable harness and fill tube routing near and around the water pump motor on all field units manufactured before July 2001 on a next call basis.

PARTS REQUIRED

Qty. 1	P/N 0638-555-01	U63 PowerSuite FRU
Qty. 2		6" Tie Wraps
Electrical Tape		

RETROFIT INSTRUCTIONS

Perform this retrofit on a next call basis.

1. Disconnect the system power cord from the AC mains.

2. Gain access to the rear panel.

Open the front door and remove the top and side covers.

Remove the rear panel assembly mounting hardware from the chassis and carefully lean the top of the rear panel assembly away from the chassis.

VERSAPULSE POWERSUITE FSB # 2: CONT.

3. Inspect/repair the cable harness.

Inspect the cable harness from the CPU board to Rear Panel I/O board near and around the backside of the water pump motor. Repair the cable harness if the heat-shrink tubing and/or insulation are worn through. Add a tie-wrap to the cable harness at the through-hole above the circuit breaker to keep the cable harness off the motor.

4. Inspect the coolant fill tank tube near and around the backside of the water pump motor.

This tube is short, so add a tie-wrap to the tubing at the through-hole above the circuit breaker or wherever convenient to keep the tube off the motor.

NOTE: Take care to not stretch or kink the tubing.

5. Replace the rear panel assembly mounting hardware, side covers and top cover.

6. Locate U63 on the CPU board and check the revision on the lable.

U63 is at the bottom of the board, just right of center. If the revision is "D", skip to step 9.

7. Remove the CPU board and locate U63.

Be sure to use approved ESD methods.

8. Remove the IC from socket U63 and carefully insert the revision "D" EPROM into the socket U63.

Pin 1 is top left of socket. Reinstall the CPU board.

9. Close the front door, connect the system power cord mains and turn on.

10. Verify the output power calibration per Section 3.6.2 and perform the Operational & Safety Checkout per Section 3.7 of the Service Manual.

Report the completion of the retrofit using Service Action Code (SAC) VP9800N on the System Certification (Service Report).

8.0 SCHEMATICS AND DRAWINGS

This section includes a complete set of schematic diagrams for the VersaPulse® PowerSuite™ laser as produced at the release of this manual, as well as selected drawings.

NAME	DRAWING #	PAGE #
Block Diagram		8-3
Functional Block Diagram		8-4
Interconnect Diagram		8-5 thru 8-6
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Fan Speed Controller PCB	0636-049-01	8-8
VersaPulse PowerSuite CPU PCB	0636-045-01	8-9 thru 8-18
Optics Bench PCB	0636-039-01	8-19
Servo Motor PCB	0636-041-01	8-20
Attenuator PCB	0636-043-01	8-21
Remote Control	0619-426-01	8-22
Power Supply Interconnect	0627-435-01	8-23 thru 8-25
Start Indicator PCB	0626-987-01	8-26

HVPS Controller PCB	0626-695-01	8-27 thru 8-32
Start / Simmer Control PCB	0626-697-01	8-33 thru 8-35
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HVPS Motherboard	0626-699-01	8-37 thru 8-39
Crowbar Driver	0626-703-01	8-40
IGBT Driver PCB	0636-171-xx	8-41
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